A TECHNOLOGICAL AND SCIENTIFIC DICTIONARY

EDITED BY

G. F. GOODCHILD

M.A. (CAMB.) B.Sc. (LOND.) PRINCIPAL OF THE WANDSWORTH TECHNICAL INSTITUTE

AND

C. F. TWENEY

LATE LIBRARIAN AND SECRETARY PUTNEY PUBLIC LIBRARY

THE GRESHAM PUBLISHING COMPANY

THIRTY-FOUR SOUTHAMPTON STREET STRAND LONDON

LIST OF THE PRINCIPAL CONTRIBUTORS

BALDRY, A. LYS	Painting and Sculpture.
BEAUMONT, PROF. ROBERTS	Woollen and Worsted Manufacture.
BELL, T. F.	Linen Manufacture.
BINNS, W. MOORE	Pottery and Porcelain.
BROOKS, E. E., B.Sc.	Radiation, Radio-activity, etc.
BROWN, REGINALD, F.C.S.	Dyes and Dyeing.
CARDER, J. G.	Glass Manufacture.
DAVEY, H. A., F.B.I.C.C.	Building Terms.
DAVIES, C. T.	Archæology.
DAVIES, F. H.	Electric Traction.
DE COVERLEY, ROGER	Bookbinding.
ELLISTON, R. J.	Types and Typography.
GOODCHILD, J. G.	Geology.
GOODCHILD, W., M.B., B.Ch.	Mineralogy.
GRIFFIN, H. H.	Motor Cycles and Motor Boats.
HARPHAM, W.	Lace Manufacture.
HEYLIN, H. B.	Cotton Manufacture.
HURTLEY, W. H., D.Sc.	Chemistry.
JENNINGS, A. SEYMOUR	Oils, Colours, Decoration.
LOCKYER, W. J. S., Ph.D.	Meteorology.
NEW, C. H., F.I.C.	Chemical Technology.
PARKER, J. GORDON, Ph.D.	Leather Manufacture.
PURCHON, W. S.	Architecture.
RHEAD, G. W.	Engraving and Etching.
SEAGER, J. A., A.I.E.E.	Electric Lighting and Electric Motors.
SENIOR, EDGAR	Photography.
SHAW, W. BOLTON, B.Sc.	Steam Engines.
SINDALL, R. W., F.C.S.	Paper Manufacture and Wood Pulp.
SMITH, P. CALDWELL, M.A., M.D., D.P.H.	Sanitation.
STANSBIE, J. H, B.Sc.	Metallurgy and Metallography.
SZLUMPER, A. W., M.Inst.C.E.	Railways.
TONGE, J., M.I.M.E., F.G.S.	Mining.
VAN STONE, J. H., F.L.S.	Botany.
WARNER, F.	Silk Manufacture.
WELLS, WHARTON, L.R.A.M., F.R.C.O.	Musical Terms and Musical Instruments.
WILLIAMS, ARCHIBALD	Speed Gears and Tyres.
WRIGHT, T. D.	Watches and Clocks.

PREFACE

THE object of the Dictionary is to furnish the modern signification of technical terms employed in the Arts and Sciences enumerated on p. vii, and by means of compendious articles to elucidate the principles and processes of pure and applied science.

The numerous articles on the various branches of Chemistry, Theoretical, Practical and Applied, as well as those on Mineralogy and Metallurgy, afford the latest information available, much of which is not to be found in earlier standard works of reference dealing with these subjects.

For explanation of or further details concerning the technical terms that occur in the longer articles, readers should refer to the general alphabetical arrangement.

Purchasers of the Dictionary are recommended to compare the *Corrigenda* with the definitions to which they refer and to make the actual corrections.

The Editors will be grateful to readers who kindly inform them of any errors not already corrected.

September, 1906.

CONTENTS

	PAGE
LIST OF PRINCIPAL CONTRIBUTORS	iii
SCOPE OF DICTIONARY	vii
KEY TO ABBREVIATIONS	viii
DICTIONARY	1—868
„ APPENDIX	869—874
„ CORRIGENDA	875

SCOPE

THE Dictionary contains Definitions of the Technical Terms most frequently employed in the several Arts and Sciences enumerated below, as well as numerous Articles, some of them of considerable length, dealing with various branches of these Arts and Sciences:

- ARCHÆOLOGY
- ARCHITECTURE
- ART
- ASSAYING
- ASTRONOMY (PURE AND APPLIED)
- BOOKBINDING
- BOTANY (ECONOMIC)
- BRICKMAKING
- BUILDING TRADES (BRICKLAYING, MASONRY, CARPENTRY, JOINERY, HOUSE-PAINTING, PAPERHANGING, PLUMBING, QUANTITY SURVEYING)
- CERAMICS
- CHEMISTRY
- CYCLE MANUFACTURE
- DYEING
- ELECTRICITY
- ENGINEERING (CIVIL, ELECTRICAL, MECHANICAL)
- ENGRAVING AND ETCHING
- GEOLOGY
- GLASS MANUFACTURE
- HERALDRY
- HYGIENE
- LAND SURVEYING
- LEATHER TANNING AND DYEING
- METALLURGY
- METEOROLOGY
- MINERALOGY
- MINING
- MOTORS AND MOTOR-CAR MANUFACTURE
- MUSIC
- OIL MANUFACTURE
- PAINT MANUFACTURE
- PAINTING
- PAPER MANUFACTURE
- PHOTOGRAPHY AND PROCESS WORK
- PHYSICS
- PRINTING
- SCULPTURE
- STEAM ENGINE CONSTRUCTION
- TEXTILE MANUFACTURES (COTTON, LACE, LINEN, SILK, WOOL, ETC.)
- WATCH AND CLOCK MAKING
- WEIGHING, MEASURING, ETC.
- WOOD PULP MANUFACTURE
- ZOOLOGY (ECONOMIC)

KEY TO THE ABBREVIATIONS USED IN CLASSIFYING THE TERMS INCLUDED IN THE DICTIONARY

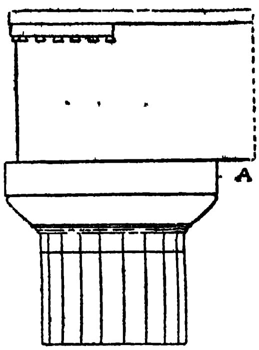
(*Archæol.*)	= Archæology
(*Architect.*)	= Architecture
(*Arm.*)	= Armour
(*Astron.*)	= Astronomy
(*Bind.*)	= Bookbinding
(*Biol.*)	= Biology
(*Build.*)	= Building
(*Carp.*)	= Carpentry
(*Chem.*)	= Chemistry
(*Chem. Tech.*)	= Chemical Technology
(*Civil Eng.*)	= Civil Engineering
(*Cost.*)	= Costume
(*Dec.*)	= Decoration
(*Elect.*)	= Electricity
(*Elect. Eng.*)	= Electrical Engineering
(*Eng.*)	= Engineering
(*Engrav.*)	= Engraving
(*Geol.*)	= Geology
(*Her.*)	= Heraldry
(*Join.*)	= Joinery
(*Math.*)	= Mathematics
(*Manufac.*)	= Manufacture
(*Mech.*)	= Mechanics
(*Met.*)	= Metallurgy
(*Meteor.*) and (*Meteorol.*)	= Meteorology
(*Min.*)	= Mineralogy
(*Paint.*)	= Painting
(*Photo.*)	= Photography
(*Phys.*)	= Physics
(*Plast.*)	= Plastering
(*Plumb.*)	= Plumbing
(*Pot.*)	= Pottery
(*Print.*)	= Printing
(*Sculp.*)	= Sculpture
(Tw.)	= Twaddell
(*Typog.*)	= Typography
(*Zool.*)	= Zoology

A TECHNOLOGICAL AND SCIENTIFIC DICTIONARY.

A (*Music*). The sixth note of the diatonic scale of C, and the first or key-note of the relative minor scale. Its Sol-Fa and Continental name is La. A is the note sounded to which all the instruments in the orchestra are tuned. On all stringed instruments it is found as an "open" string—that is, the note to which a string is tuned. One of the clarinets is in the key of A, the other two being respectively B♭ and C.

"A" Frame (*Eng.*) A triangular frame with a cross bar forming the supports of some part of a machine or other structure.

Abacus (*Architect.*) The uppermost member or feature of the capital of a column. It supports the architrave (*q.v.*) In the Doric, Tuscan, and ancient Ionic orders it is merely a flat square slab; but in the Corinthian and Composite orders it is shaped differently, and ornamented. *See* COLUMN, CORINTHIAN, COMPOSITE.



A, ABACUS (GRECIAN DORIC).

Abaissé (*Her.*) Not in its usual place in a shield, but lowered.

Abatements (*Her.*) Marks of degradation, not now used; cf.:

> Yea though I die, the scandal will survive,
> And be an eyesore in my golden coat;
> Some loathsome dash the Herald will contrive
> To cipher me.
>
> SHAKESPEARE.

Abatjour (*Architect.*) A sloping aperture made in a wall for the purpose of admitting light to basements and such other apartments.

Abattoirs. Abattoirs, or public slaughter houses, are of great importance in the regulation of our meat supply by providing a means whereby the meat can be closely examined before being sent to the market. They are under the control of the sanitary authorities, who are empowered by the Public Health Acts to make byelaws for the licensing, registering, and management thereof. It is most essential that the drainage, water supply, and ventilation be kept in efficient order, and that all waste refuse be immediately removed.

A Battuta (*Music*). With the beat.

Abatvoix. The canopy or sounding board over a pulpit or rostrum to deflect the sound of the voice.

Abb (*Weaving*). West of England term for "weft," *i.e.* the yarn or thread used in weaving for crossing and interlacing with the warp. This term is also applied to a certain quality or sort of fleece.

Abbey. A church attached to a monastery or convent: a name given to a church that once belonged to a religious community—*e.g.* Westminster Abbey.

Abbozzo (*Paint.*) The first sketch or rough draft of a picture.

Abdomen (*Zoology*). The posterior part of the trunk of an animal. It is unprotected by a bony framework on the belly or under (ventral) surface.

Abdominal Pores (*Zoology*). A pair of apertures, one on each side of the cloaca (*q.v.*) of fishes of the Shark family. These openings communicate with the body cavity.

Aberdeen Granite. *See* BUILDING STONES.

Aberration (*Light*). An apparent displacement in the position of a body, owing to the observer's motion while light is travelling from it to the observer. It was first noted in connection with the supposed "Fixed" stars.

——, **Chromatic** (*Light*). The splitting up of light into its component colours (or DISPERSION, *q.v.*) by a lens, owing to the different refractive index of each component. This gives an image with a coloured margin. Corrected by suitably combining two lenses of different glass. *See* ACHROMATISM.

——, **Spherical** (*Light*). The meeting of reflected or refracted rays in a succession of points, instead of in one single point, which results from the reflecting or refracting surface being spherical. This error is corrected by modifying the form of the surface (*e.g.* mirrors are made of parabolic, instead of circular, section).

Abezzo, Olio di (*Paint.*) An oil produced from the pine tree, used as varnish.

Abney Level. A form of reflecting level and clinometer combined.

Abococke (*Cost.*) A hat pointed in front, with the brim turned up behind, worn by royal personages during fourteenth to sixteenth centuries.

Abolla (*Cost.*) A loose cloak made of wool, especially used by the Stoic philosophers.

About Sledge (*Eng.*) The use of a double-handed or "sledge" hammer for the delivery of heavy blows by swinging it above the head.

Abrasion. Rubbing away, or grinding, of some material. The action of a grindstone and emery or glass paper may be quoted as examples.

N.B.—It will be noted that no medical or anatomical definitions are given in the DICTIONARY. For example, in the case of **Abdomen** only the zoological meaning is signified.

Abraxas (*Archæol.*) Gems on which the mystic word Abraxas was graven, used as charms by the Gnostics about the second century.

Absinth. A liquor prepared from the leaves and flowers of Artemisia or wormwood (one of the *Compositæ*), together with other aromatic herbs; yellowish-green colour. Contains oil of wormwood as distinctive ingredient; flavouring oils such as peppermint, cloves, etc.; alcohol (about 50 per cent.)

Absolute Alcohol (*Chem.*) *See* ALCOHOL.

Absolute Pressure (*Phys.*) Pressure measured from the true zero or absolute vacuum. Thus a steam pressure commonly quoted as 50 lb. per square inch is 65 lb. if measured from the absolute zero or true vacuum, but is 50 lb. more than the pressure of the atmosphere.

Absolute Strength (*Eng.*) The total load necessary to break a piece of material.

Absolute Temperature (*Phys.*) Temperature measured from the absolute zero (*q.v.*) This is about 274° C. or 493° F. below the melting point of ice. Thus 20° C. = 274° + 20° = 294° absolute on the Centigrade scale; 62° F. = 62° − 32° + 493° = 520° absolute on the Fahrenheit scale.

Absolute Unit of Current (*Elect.*) A current which exerts unit magnetic force (1 dyne per unit pole) at the centre of an arc of the conductor carrying the current, the arc being of unit length (1 cm.) and unit radius. This unit is too large for practical use, and the Ampère, which is one-tenth of an absolute unit, is used instead.

Absolute Units (*Phys.*) Units connected by a simple physical relation with certain fundamental units, usually three in number, the units of Time, Length, and Mass. Thus a unit of volume directly derived from the unit of length is an absolute unit—*e.g.* a cubic foot or cubic centimetre. A poundal or a dyne (*q.v.*) is also an absolute unit of force, while the weight of a pound or of a gram is not, since it depends on the force exerted by gravity at the place as well as on the fundamental units.

Absolute Zero (*Heat*). The temperature at which no heat would remain in a body. It is found that this would be the case if we could cool a substance to −273° or −274° on the Centigrade scale. At this temperature the vibrations constituting the heat energy of the substance would have entirely ceased. The absolute zero has been approached to within about 25°; *i.e.* bodies have been cooled to − 250° C.

Absorptiometer (*Phys., Chem.*) An instrument for measuring the solubility of gases in water or other liquids.

Absorption (*Physiology*). The term applied to the process by which the soluble food materials in the stomach and intestines become diffused into the blood (*see* ILEUM, VILLI). In Botany the term used for the process by which the soil water passes into the roots. *See* ROOT.

——, **Electrical.** The storing up of a part of the electrical energy of a charged condenser by the dielectric (*q.v.*) This stored energy becomes manifest after the condenser has been discharged once by giving a second smaller discharge, followed by others still smaller. These apparent successive charges are called "Residual Charges" (*q.v.*)

Absorption of Gases, Coefficient of (*Phys.*) The volume of a gas which can be absorbed by unit volume of a given liquid at 15° C.

Absorption of Light. When light falls upon a medium, a part is usually retained or absorbed by the medium. The energy of the absorbed light commonly, though not always, is retained by the body in the form of heat; it may, however, produce some chemical change or, in the case of organic media, some physiological change.

Absorption Spectrum. *See* SPECTRUM ANALYSIS.

Absorption, Thermal. The power of a surface to absorb heat falling upon it.

Absorptive Power (*Heat*). The fraction of the total amount of heat falling upon a body, which is absorbed by the body.

Abt Rack (*Civil Eng.*) *See* MOUNTAIN RAILWAYS.

Abutments (*Eng., etc.*) Surfaces of a structure which support the load—*e.g.* the top of the piers carrying the girders of a bridge, or the part of the masonry from which an arch springs *See* ARCH.

Abyssinian Gold. A gold-plated alloy of copper and zinc.

Acacia. *See* WOODS.

Academic (*Art*). What is drawn according to rule, correct, but formal and uninspired. Academic size, a little less than half size.

Academician. A member of an academy. A Royal Academician (*R.A.*) is one of the forty members who, with a certain number of Associates, constitute the Royal Academy in England.

Academy. Originally the grove or garden near Athens where Plato taught. Now generally used for a school or a place of instruction.

——, **Royal.** Founded by George III. in 1768, under the title of the "Royal Academy of Arts in London." Established until 1834 at Somerset House, then in Trafalgar Square, since 1869 at Burlington House, Piccadilly. Consists of forty Academicians styled "R.A." and thirty Associates styled "A.R.A." The annual exhibition of pictures by living artists opens on first Monday in May, and continues until first Monday in August. Works that have once been exhibited are not again accepted for this exhibition. The winter exhibition, consisting of loan collections, etc., is open from the beginning of January until the middle of March. In the building are schools of art for male and female students. The following is a list of Presidents, with date of election: Sir Joshua Reynolds (1768); Benjamin West (1792); Sir Thomas Lawrence (1820); Sir M. A. Shee (1830); Sir C. Eastlake (1850); Sir Francis Grant (1866); Lord Leighton (1878); Sir John Everett Millais, Bt. (1896); and Sir E. J. Poynter, Bt., the present occupant of the office (1896).

Acanthus (*Architect.*) A conventional ornament used in Greek, Roman, and Renaissance architecture. It resembles the foliage of the plant of the same name. There are two types of acanthus: the "prickly," having pointed leaves, and used by the Greeks; and the olive acanthus, which has blunt leaves, and was used in Roman work. *See* COMPOSITE, CORINTHIAN.

A Capriccio (*Music*). At the caprice of the performer.

Accelerando (*Music*). Gradually quickening the speed.

Acceleration (*Phys., Mech.*) The increase of velocity per unit of time: more exactly, the rate of increase of velocity.

Accent (*Music*). Stress, prominence.

Accent (*Typog.*) A mark placed over a letter either to qualify its sound or to denote abbreviation; thus, é acute, è grave, ê circumflex, ë diæresis, ē long, ĕ short.

Acciaccatura (*Music*). A crushed note. It is distinguished from the Appoggiatura by having a stroke through its tail, and is played as a very short note.

Accidental Lights (*Paint.*) Rays of light which make some parts of the picture more prominent than the rest.

Accidentals (*Music*). Signs used during a piece to temporarily alter the pitch of a note. *See* SHARP, FLAT, NATURAL.

Accident Cranes (*Eng.*) *See* CRANES.

Accipenser (*Zoology*). A genus of the sturgeon tribe of Ganoid fishes. *A. sturio*, the common sturgeon, is a valuable food fish, and is also the source of ISINGLASS and CAVIARE (*q.v.*)

Accolé (*Her.*) is the term used by the French heralds for "collared." It also means two separate shields placed side by side—*e.g.* the knight of an order on marriage.

Accosted (*Her.*) When charges are placed side by side.

Accrued (*Her.*) Full grown, as of a tree.

Accumulator (*Eng.*) A vessel used for storing water under pressure to be used for driving hydraulic machinery. Usually consists of a vertical cylinder with a piston carrying a heavy load on the top of the piston rod.

——, **Electrical.** An accumulator, or, as it is otherwise called, a STORAGE CELL or SECONDARY CELL, is an arrangement by which electrical energy can be stored up. It consists of surfaces of lead which are coated with one of the lower oxides of lead (red lead or litharge). The leaden plates thus coated are placed in dilute sulphuric acid, and are then charged by the passage of a strong current of electricity for some considerable time. Chemical action of a kind described below occurs, and, when this is complete, the cell is fully charged. On disconnecting the wires by which it is charged, the cell will retain its energy for a considerable time; and on connecting up to any electrical apparatus, it will furnish a current with a voltage of about 2·1 volts for each cell, and this goes on until the cell is exhausted, the time taken depending upon the rate at which the current was taken from the cell. The cell can now be re-charged and the operation repeated a great number of times.—CHEMICAL ACTION IN THE CELL: The leaden plates appear first of all to become covered with a layer of lead sulphate, formed by the action of the sulphuric acid on the lead and lead oxide, with which they were originally coated. When the charging current is passed through the cell, the dilute sulphuric acid is broken up into anions, consisting of SO_4, and cations of H (nascent hydrogen). The hydrogen ion appears at the cathode or plate by which the current is leaving the cell; it attacks the lead sulphate, and gradually reduces it to a layer of metallic lead, which is left in a finely divided and spongy condition. The SO_4 ion travels to the anode, where its oxygen oxidises the lead compound to lead peroxide (PbO_2). When all the lead sulphate which is available has been acted on in this manner, the hydrogen and oxygen are set free at the plates in the gaseous form, and bubble up through the liquid, showing that the charging process is now complete, and the current may be cut off. When the cell is discharged it sends a current in the opposite direction to the one used for charging, and has a potential difference between the plates of about 2·1 volts at the start, and this gradually falls to about 1·8 volts by the time the cell is practically exhausted. Accumulators provide a chemical method of storing electrical energy, about 80 per cent. of the energy used in charging being recovered. The rate at which the energy is recovered depends entirely upon the amount of current taken from the cell, and the capacity of a cell is usually estimated in "AMPÈRE HOURS": thus, if we say that the capacity of a cell is 100 Ampère hours, we mean that it can supply 1 Ampère for 100 hours, 2 Ampères for 50 hours, 5 Ampères for 20 hours, and so on. One of the great objections to storage cells is the great weight, owing to the use of large masses of lead. The metallic lead in the cell only serves as a support for the lead compounds taking part in the reactions, and theoretically these leaden supports may be reduced to comparatively small weight; but in practice it is not safe to make the plates too slender in structure, as their surfaces are always attacked to some extent by the actions which are going on, and they would easily fall to pieces unless made fairly substantial. The actual weight of a cell which is required to furnish a certain number of Ampère hours depends upon the proportion between the active material of the cell and the inactive material or metallic lead which is unchanged during the action of the current. In the original cells used by Planté the coating of oxides of lead was formed by immersing ordinary leaden plates in a dilute acid, passing the current, then discharging, and repeating this process a number of times. Cells made in this way are sometimes termed "Formed cells," and their capacity may be put down as being from 6 to 9 Ampère hours per pound weight. In the later forms of cell which were introduced by Faure the active material consists of a paste of oxides of lead supported in frames or grids of lead. It is easily seen that in this case the amount of active material must be very much greater, and, as a matter of fact, the capacity of these "Pasted cells," as they are called, is from 10 to 15 Ampère hours per pound weight of cell.—MANUFACTURE OF CELLS: It is impossible to describe in detail the great variety of processes used in the production of different cells, and one example only is given—that of a modern form of "Chloride cell." Lead chloride specially prepared is fused and cast into small tablets of the shape of a hexagon. These tablets are arranged on a frame, leaving regular spaces between them, being held in place on the frame by small pins which fit into holes cast in each tablet. The spaces between the tablets are now filled up by pouring metallic lead in under great pressure. On cooling, there is then produced a strong frame of lead carrying a great number of lead chloride tablets, so that the greater part of the surface of each plate will consist of the chloride. The lead chloride is then reduced to metallic lead by the action of zinc in a solution of zinc chloride, and a final result is to produce a leaden plate consisting of a great number of small masses of very porous lead held in place by a kind of honeycomb of solid lead. The plates are then ready for their first charging.—EDISON'S STORAGE CELL: Many inventors have endeavoured to reduce the weight of accumulators, and Edison in some recent patents has made considerable progress in this direction. As the result of a great number of experiments, he has abandoned the use of lead altogether. The

positive plate consists of a light perforated case of sheet nickel serving as the support, and containing oxide of nickel as the active material. The negative plate also consists of a nickel case, but contains very finely divided iron, which has been reduced from the sulphate or hydrate. The liquid used in this case is a solution of an alkali; for example, NaOH in water. This cell appears to have a very much greater capacity in proportion to its weight than the ordinary pattern of storage cell; but up to the present it has hardly passed beyond the experimental stage.—G. F. G.

Acerra (*Archæol.*) The small box in use at sacrifices to hold incense, and from which the incense was poured on the burning sacrifice.

Acetabulum (*Archæol.*) A vinegar cup. Applied to all small vases wide and open, whether made of earthenware or metal. Also used by jugglers.

—— (*Zoology*). The socket in the hip girdle for the articulation of the femur or thigh bone.

Acetal, $CH_3CH(OC_2H_5)_2$. A compound formed by the union of 1 molecule of aldehyde with 2 molecules of alcohol. It is a pleasant-smelling liquid.

Acetaldehyde, CH_3CHO. Formed by heating a mixture of calcium formate and acetate; also by oxidising alcohol with chromic acid. It is a liquid boiling at 20° C. It has a peculiar smell, its vapour producing cramp of the respiratory muscles. It has the properties of an aldehyde (*q.v.*) On polymerisation it forms (*a*) paraldehyde $(CH_3CHO)_3$, a liquid which is a valuable sleep-producing agent; (*b*) in the cold, a solid metaldehyde $(CH_3CHO)_n$.

Acetamide, CH_3CONH_2. White crystals smelling strongly of mice, unless pure; melts at 82·3°; readily soluble in water and alcohol; less soluble in ether. *See also* AMIDES.

Acetanilide, $C_6H_5NHCOCH_3$ (*Antifebrin*)) A scaly crystalline solid formed by boiling aniline and glacial acetic acid together. It is poisonous. Contained in "Headache" or "Daisy" powders. It relieves pain to some extent, but depresses the heart, and should not be taken unless under medical advice.

Acetic Acid, CH_3COOH. A liquid which solidifies at 16·7° C. It is formed when weak alcohol, such as wine or malt liquor (beer), ferments under the influence of the myooderma aceti (mother of vinegar) in presence of air. The dilute acetic acid so obtained is called wine vinegar or malt vinegar respectively, and contains 5 to 15 per cent. acetic acid. The strongest acid, called glacial acetic acid (97 per cent. and over), is obtained from the pyroligneous acid produced in the destructive distillation of wood; has a powerful smell, and blisters the skin.

Acetic Anhydride, $(CH_3CO)_2O$. The anhydride of acetic acid. It is obtained by the action of phosphorus oxychloride on sodium acetate. A liquid boiling at 137°. A very important reagent in organic chemistry; used to introduce acetyl groups into hydroxyl and amino compounds, and as a condensing agent.

Acetic Ether. *See* ETHYL ACETATE.

Acetone, CH_3COCH_3 (*Dimethyl Ketone*). A liquid with characteristic smell; boils at 56°; obtained by heating barium or calcium acetate, and on the large scale from wood spirit (*q.v.*) It is used in making chloroform, iodoform, and sulphonal. The breath and urine of persons suffering from diabetes smell of acetone, and the latter occurs in considerable amount in diabetic urine. *See* KETONES.

Acetonitrile. *See* NITRILES.

Acetophenone, $CH_3COC_6H_5$ (*Phenylmethyl Ketone*; also called *Hypnone*). A low melting (20·5° C.) solid with persistent smell of oil of bitter almonds. In small doses it produces sleep. *See* KETONES.

Acetyl Chloride, CH_3COCl. This is the chloride of acetic acid, and is obtained by acting on the latter with phosphorus trichloride. It is a colourless, strongly fuming liquid of great value in organic chemistry for ascertaining the presence of hydroxyl and amino groups in compounds and in the preparation of ketones and tertiary alcohols.

Acetylene, C_2H_2. A gas which burns in air with a very bright flame; hence its use as an illuminant. Only slightly poisonous. Air containing 20 per cent. of it proves fatal to dogs. It does *not* combine with the hæmoglobin of the blood. Mixed with the proper proportion of air (1 : 12·5), it explodes with extreme violence on ignition; also decomposed by shock. Coal gas contains ·06 per cent. It is formed by the action of water on calcium carbide, when coal gas is incompletely burned, and when alcoholic potash is heated with ethylene bromide.

Achene (*Botany*). A one-seeded, dry, indehiscent fruit, such as the "seed" of the sunflower.

Achlamydeous (*Botany*). When both whorls of the perianth of a flower are absent.

Achromatic Lens. A lens which is corrected so as to bring the coloured rays which are of the greatest importance to a common focus. These rays are not the same in photography as those which are used in telescopes or microscopes, as the rays of greatest photographic importance are distinct from those which are most active in producing vision.

Achromatism (*Light*). The property of transmitting a beam of light without splitting it up into any of its component colours. Produced in lenses by a combination of two, or more, lenses of different kinds of glass, in most cases by a convex lens of crown glass and a concave lens, of less power, of flint glass.

Acicular (*Botany*). A term applied in the description of a leaf when it is long and needle-like. as in the pine.

Acid (*Chem.*) An acid is a compound which, when in aqueous solution, contains hydrogen in the ionic condition. Popularly speaking, an acid is a substance having a sour taste, turning blue litmus red, forming with basic oxides a salt and water, and often having its hydrogen replaced by direct action of certain metals, again forming a salt. When an acid forms only one salt with a monovalent metal, it is called monobasic; when only two salts, dibasic, etc.

Acid Dyes (*Chem.*) Dyes which, in order to fix them upon a fabric, require to be combined with a substance of basic character. They are generally phenols (*q.v.*) or sulphonic acids (*q.v.*) *See also* DYES AND DYEING.

Acidimetry (*Chem.*) The determination of the amount of acid in any given substance by adding a solution of an alkali of known strength from a burette to a solution of the substance until the acid is just neutralised. The neutral point is ascertained by adding to the acid solution a drop or two of a suitable indicator. *See* INDICATORS.

Acid Oxides (*Chem.*) *See* OXIDES.

Acid Process (*Metallurgy*). The early form of the Bessemer process of steel making, in which the converter had a lining containing a high percentage of

silica. This silicious or "acid" lining fails to remove phosphorus from the iron, and has been replaced by the "Basic Process."

Acid Pump (*Chem.*) A pump with internal parts made of glass or earthenware, so as to be unaffected by acids.

Acid Rocks (*Geol.*). A term referring to the chemical composition of certain rocks of eruptive origin. These consist mostly of silicates of various bases, in which the proportion of silica, which functions as the acid element, to the base is subject to a wide range. Those cases in which the percentage of silica falls below 55 or 60 are referred to as BASIC; those in which it is between 55 and 65 are spoken of as INTERMEDIATE; while the rocks in which a higher silica percentage obtains are the ACID ROCKS here specially referred to.

Acierage (*Engrav.*) A process by which a very thin layer of steel is deposited on the face of an engraved copperplate so that it may stand the wear and tear of printing; somewhat similar to electroplating.

Acinaces (*Archæol.*) A Persian sword, short and straight like a dagger, generally worn against the right thigh.

Ackerman Axle (*Motor Cars*). The original type of most forms of steering in cars. The main shaft is rigidly fixed to the car, short-axles are pivoted or hinged to the ends of this, and on these short axles the hubs of the wheels run. The hinges are operated by levers connected with the steering wheel. The pivot or hinge varies in form, and is the subject of various patents.

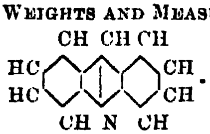
Acketon, Aketon, Hacketon (*Cost.*) A quilted garment worn over the shirt to prevent armour from injuring the body.

Aconite (*Botany*). *Aconitum napellus* (order, *Ranunculaceæ*). The preparations of aconite are made from the dried root, the fresh leaves, and the young inflorescences.

Aconitine, $C_{21}H_{27}.(OCH_3)_4.NO_5.COCH_3.COC_6H_5$. An alkaloid obtained from aconite root (monk's hood or wolf's bane). It is a crystalline solid, intensely poisonous. Externally it causes tingling numbness and local anæsthesia; internally, tingling numbness, vomiting. It dilates the pupils of the eye.

Acratophoron (*Archæol.*) A vessel for holding pure wine, *i.e.* unmixed with water.

Acre. *See* WEIGHTS AND MEASURES.

Acridine, 

A white crystalline solid occurring in coal tar. Inhaled, it causes sneezing. Its solutions show a blue fluorescence. Some of its derivatives are important as dyes.

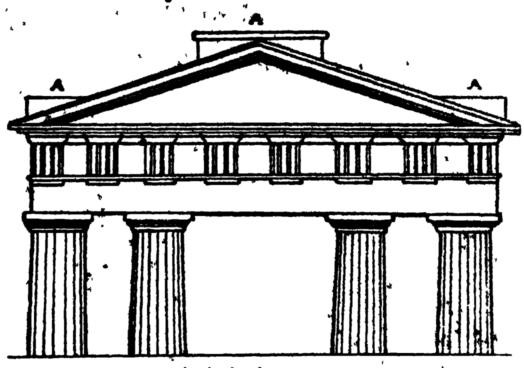
Acrolein, $CH_2:CH.CHO$. A colourless mobile liquid boiling at 52°; it has an extremely pungent smell. Its chemical behaviour is that of (1) an unsaturated compound (*q.v.*), (2) an aldehyde (*q.v.*) It is formed when glycerine is heated with water, abstracting reagents such as sulphuric acid or potassium acid sulphate.

Acromion (*Zoology*). A process at the end of the ridge on the outer surface of the scapula or shoulder blade.

Acropolis (*Architect.*) The citadel of a Greek city, usually situated at the summit of the hill upon which the city was built.

Acrostolium (*Archæol.*) "At the head of the prow there projected the stolos, and its extremity, which was frequently made in the shape of an animal or helmet, was called acrostolium. It is sometimes designated by the name cheniscus" (*q.v.*).—SMITH.

Acroterium, *pl.* **Acroteria** (*Architect.*) Small pedestals resting on the angles of a pediment and intended to carry statues or other ornaments.



A, A, A, ACROTERIA.

Acrylic Acid, $CH_2:CH.COOH$. A liquid boiling at 140°, and smelling like acetic acid; formed by oxidation of acrolein with silver oxide and by abstracting water from hydracrylic acid.

Actaeon. *See* ARTEMIS.

Actinolite (*Min.*) A variety of Amphibole (*q.v.*) occurring usually in fibrous and radiated crystalline masses (*Actinotos*, radiated). Common in metamorphic rocks. A silicate of iron, calcium, and magnesium. Monosymmetric. Composition: $3(Mg.Fe)O.SiO_2.CaO.SiO_2$.

Actinometer (*Photo.*) An instrument for measuring the photographic intensity of light, and hence the time of exposure. It usually depends on the observation of the time necessary to darken a sensitised strip of paper.

Actinomorphic (*Botany*). The term used when a flower is radially symmetrical—that is, when the flower can be divided into similar halves by two or more planes passing through an axis.

Action at a Distance (*Physics*). Phenomena such as electric and magnetic attractions and repulsions were supposed by the older physicists to be due to some obscure power of action at a distance. Such forces are now explained by the existence of stresses and strains in the medium connecting the bodies acted on. *See* LINES OF FORCE.

Active Current (*Elect. Eng.*) The component of an alternating current which is in phase with the impressed electro-motive force. If C is the full amount of current and ϕ is the angle of lag, then the active current is $C \cos \phi$.

Acuminate (*Botany*). The term applied to the apex of a leaf when it is drawn out to a point.

Acus (*Archæol.*) A needle or pin, generally made of metal.

Acute Accent (*Typog.*) A mark placed over a letter, thus é: opposed to grave.

Acute Angle. One less than a right angle (90 degrees).

Adagio (*Music*). Slow, leisurely.

Added Sixth (*Music*). The common chord on the Subdominant, with an interval of a sixth from the bass added: also called the third inversion of the Dominant 11th.

Addendum (*Eng.*) The point of a wheel tooth or part outside the pitch circle (*q v.*)

Addorsed, Adorsed (*Her.*) Back to back; the opposite of *affronté*.

Adhesive Power (*Eng.*) The friction between the driving wheel of a locomotive and the rail which prevents slipping. Varies from one-fifth to one-twelfth of the weight, according to the state of the rails, being least when the rails are moderately wet or "greasy."

Adiabatic Change (*Phys.*) Any change in the pressure and volume of a gas during which no heat is allowed to enter or leave.

Adiabatic Curve (*Phys.*) A curve showing the relation between the pressure and volume of a gas when no heat is allowed to enter or leave while the gas is compressed or expanded. (This relation is expressed algebraically by the equation $PV^\gamma =$ constant, where γ is the ratio of the specific heats at constant pressure and constant volume.)

Adipose Tissue (*Zoology*). The term applied to the connective tissue, whose cells are distended by fat drops. Fatty tissue forms a thick layer beneath the skin of animals and also around the kidneys.

Adit (*Mining*). A passage or "level" from the open air into a mine; if it runs to the vein, it is termed a "tunnel."

Adjustable Level. A level (*q.v.*) in which the tube containing the bubble can be moved through a small angle relatively to the "stock" or case, in order to get the axis of the tube accurately parallel to the sole or base of the instrument. The levels on surveying instruments are always made adjustable.

Adjusters, Chain (*Cycles*). Small bolts with eyes through which the back axle passes, and by means of which the latter can be moved in the slots of the fork ends.

Adjusting Screw. A fine threaded screw for regulating the position of some part of a machine or piece of apparatus.

Adjustment of Brushes (*Elect.*) *See* BRUSHES.

Adjutage, Ajutage (*Eng.*) An outlet for the flow of a liquid from a vessel.

Ad Libitum (*Music*). (1) At the pleasure of the performer. (2) The part *ad lib.* may be omitted.

Admission (*Eng.*) The moment at which steam enters a cylinder; also the whole period during which it is entering.

Admission Corner (*Eng.*) The part of an indicator diagram (*q.v.*) showing the entrance of the steam. For a rapid entry of steam the corner should be sharp and square; if too much rounded, it shows that steam enters too slowly, that is, the admission port is opened too late or is too small.

Admission Line (*Eng.*) The side of the indicator diagram showing the conditions while steam is entering. It should be nearly upright. *See* INDICATOR DIAGRAM.

Admission Port (*Eng.*) The passage by which steam enters the cylinder of an engine.

Admission Valve (*Motor Cars*). *See* PETROL ENGINE.

Adrenal Body (*Zoology*). The adrenal or supra-renal body is a small organ found in relation to the kidney. An extract is used in medicine.

Adriatic. *See* BUCENTAUR.

Adularia (*Min.*) A colourless sub-transparent variety of orthoclase, one of the felspars (*q.v.*) A sub-variety is MOONSTONE, so called from its pale moonlight-like lustre.

Adulteration of Food. This important matter is regulated by various legislative enactments in force throughout the country. These are: Sale of Food and Drugs Act, 1875; Sale of Food, etc., Amendment Act, 1879; Margarine Act, 1887; Sale of Food and Drugs Amendment Act, 1899. In order to see that these Acts are not contravened, samples are taken and analyses made by the local authorities. The experience is that nearly all our foods are adulterated, generally by the admixture of foreign ingredients. Milk is the food that is chiefly adulterated. Being of the highest dietetic value, and constituting, as it does, the principal food of children up to some eighteen months of age, it is extremely important that no contamination should take place.

Advancing Ignition (*Motor Cars*). Causing the spark to ignite the charge sooner. This is effected by turning the contact breaker on the secondary shaft (*q.v.*), so that it comes sooner into contact with the ignition cam (*q.v.*) By turning the contact breaker in the opposite direction, the spark (and therefore the ignition) is retarded.

Adventitious (*Botany*). The term used when an organ is developed out of its proper order, as in buds where developed without relation to leaves, or in roots where they arise on stems, leaves, etc.

Adze (*Carp.*) A tool of the nature of an axe, but with the plane of the blade at right angles to the axis of the handle. Used for cutting broad surfaces of wood, and formerly a common tool in shipyards.

Adze Block (*Carp.*) The part of a wood-planing machine which carries the cutters.

Ægipan. Beasts fashioned partly like men, but having the horns and feet of a goat: satyrs.

Ægis (literally, *Goat skin*). The shield carried by Jupiter and Minerva, made of the skin of the goat Amaltheia, with a gorgon's head in the centre. Also a breastplate worn by Roman emperors.

Æolian Rocks (*Geol.*) The majority of the derivative rocks composing the stratified formations have been formed and deposited by the direct and exclusive agency of water; but in regions where an arid climate prevails the agency of the wind comes largely into play, both in giving form to the constituents of rocks and in their final distribution afterwards. Many sandstones belonging to the New Red, and some belonging to the Old Red, are of Æolian origin.

Aërial Rocks (*Geol.*) A term applied to certain rocks which have been formed on the surface of the land, and not beneath water, or in connection with ice. It is usually applied to such rocks as peat, blown sand, clay with flints, screes, rain wash, dust deposits, and the like; but it is not generally used in referring to the products of volcanic action.

Aërobic (*Botany*). The term used for those bacteria which live only in the presence of oxygen.

Æsculapius. God of medicine. He is represented with a staff and a serpent.

Æsthetics (*Art*). Perception or appreciation of the beautiful.

Æstivation (*Botany*). The term applied to the arrangement of the parts of a flower bud before the flower opens.

Affetuoso (*Music*). With feeling.

Affinity (*Chem.*) Is the name given to the unknown cause which determines the occurrence of a chemical change. While the nature of affinity is unknown, something is known of the conditions affecting its action—such are temperature, pressure, light, etc.; and something is known of the laws of its action—such as the law of mass action (*q.v.*)

Affronté, Affronted (*Her.*) Of two animals when facing each other; of one animal when it is full faced.

After Blow (*Met.*) The forcing of air into a Bessemer converter after the carbon has been removed, in order to oxidise the phosphorus. In the acid process (*q.v.*) the after blowing was apt to injure the iron by setting up oxidation. In the basic process (*q.v.*) there is less risk of this.

After Burning (*Gas Engines*). The continued combustion of the charge after the explosion has occurred.

After Damp (*Mining*). The name given by miners to the gases produced by an explosion in a coal mine. Among them are carbon dioxide, which is not very poisonous, but would cause death from asphyxia when present to the extent of about 10 per cent. by volume; and carbon monoxide, which is intensely poisonous.

After Flush (*Plumbing*). The after flush performs an important function in "sealing" up the trap of the water closet after the contents of the basin have been discharged into the soil pipe. If this was not done, foul air would gain access to the water closet apartment, and be then ventilated into other parts of the house.

Agar-Agar. A nutritive jelly used in bacteriological work, derived from various Red Sea weeds (*Rhodophyceæ*). *Gracilaria lichenoides* yields the Ceylon agar, while *Eucheuma spinosum* is the source of the Java agar.

Agate (*Min.*) Chalcedony having a well banded appearance; now more often confined to chalcedony deposited in the vapour cavities of lavas. MOSS AGATE contains fine dendrites of oxide of iron. VEIN AGATE and RIBBON JASPER are usually forms of chalcedony deposited in veins. Agates are much used as ornamental stones. *See also* PRECIOUS STONES.

Ageing of Transformer Cores (*Elect. Eng.*) The deterioration of cores by use. The magnetic properties of the iron gradually decay, and the loss of energy by hysteresis (*q.v.*) becomes greater.

Agglomerate (*Geol.*) It was formerly the custom to name all the coarser materials arising from the explosive eruptions of volcanoes AGGLOMERATE, whether they had fallen back within the volcanic vent or outside of it. Latterly it has been deemed advisable to employ the term TUFF for the latter, irrespective of the size of the fragments, and to use the word AGGLOMERATE for the fragmentary material, whether coarse or fine, that fills the volcanic vent or NECK.

Aggregate (*Building*). Ballast, broken bricks, etc., that are mixed with lime or cement to form concrete.

Agitato (*Music*). Agitated.

Agitator (*Met.*) A stirrer used to mix the contents of the Bessemer converter after pouring out. Also applied to stirrers in various chemical manufacturing processes.

—— (*Paper Manufac.*) A paddle used for mixing the paper pulp in the stuff chest.

Agonic Line (*Magnetism*). A line drawn on a map connecting places at which there is no magnetic declination—*i.e.* where the compass needle points due north.

Agora. The public square and place of assembly in ancient Greek towns, corresponding with the "Forum" of the Romans.

Aich Metal (Gedge's Metal). An alloy resembling brass: copper, 60; zinc, 38·2; iron, 1·8.

Aiglets, Aglet (*Cost.*) A tag of metal (termed a point) used on fastenings of costume or armour.

Aigrette (*Cost.*) Called after the beautiful crest of feathers on the egret at the nesting season. Applied to a spray of feathers worn in a head-dress, or a tuft in a helmet, or a spray of gems as worn by Eastern princes.

Ailette (*Armour*). A wing-like projection from the shoulder, made of leather, but sometimes of steel. On it was emblazoned a charge from the coat of arms of the wearer.

Ailsenite (*Min.*) A rare sulpho-bismuthinite of lead and copper, $3(PbCu_2)S \cdot Bi_2S_3$. Occurs in blade-like crystals in a quartz matrix with native gold and some nickel ores in Siberia.

Air. *See* ATMOSPHERE.

Air Belt (*Met.*) A channel running round a cupola furnace (*q.v.*), from which the air enters the furnace by a number of openings, thus obtaining a more uniform distribution of the blast than is possible from two or three tuyers or nozzles.

Air Blast (*Elect. Eng.*) Used (1) for cleaning parts of dynamos from dust; (2) for blowing out the spark at a commutator.

Air Brake (*Eng.*) A brake in which the blocks are moved by pistons actuated by air pressure.

Air Brick (*Building*). A brick perforated with holes for ventilation.

Air Casing (*Eng.*) A space surrounding a flue, boiler, etc., intended to prevent the undue transmission of heat to surrounding objects.

Air Channels (*Met.*) Spaces beneath the hearths of various furnaces, serving the same purpose as an air casing (*q.v.*)

Air Compressor (*Eng.*) A pump for driving air under pressure into a reservoir for use in ventilation or to supply motive power.

Air Cooling (*Eng.*) Term applied to petrol motor engines in which the waste heat from the cylinder is dissipated into the air by means of flanges and corrugations on the cylinder itself. Only small engines are air cooled; larger ones are water cooled (*q.v.*)

Air Crucible Furnace (*Met.*) *See* BRASS FURNACE.

Air Cushion (*Eng.*) In high-speed engines, when made single acting, the piston compresses a quantity of air which is enclosed in the opposite end of the cylinder; this prevents the stresses in the reciprocating parts from being reversed, and therefore keeps

the reciprocating parts from the shocks which reversals of stress would cause. In the Willans engines, much used for electric lighting work, the piston rod and its adjuncts are kept in compression; in Mather & Platt's high-speed electric lighting engines the rods are in tension during both strokes.

Air Cylinder (*Plumbing*). An air chamber in a valve closet to regulate the flush.

Air Engine (*Eng.*) An engine in which the piston is moved by air heated in a large vessel (partly corresponding to the boiler of a steam engine). Air engines are practically obsolete even for the smallest powers.

Air Feed Pumps (*Motor Cars*). Small pumps for keeping up the air pressure in the fuel tanks of steam cars; this air pressure is needed to drive the oil fuel to the burner.

Air Flue (*Building*). A flue formed in a chimney stack for extracting the foul air from a room. *See also* ARNOTT'S VALVE.

Air Gap (*Elect. Eng.*) The narrow space between the pole pieces and the iron of the armature, or any gap (containing no iron) in a magnetic circuit.

Air Gate (*Foundry*). A vertical hole in a mould allowing the free escape of air while the molten metal is being poured in.

Air Hole (*Eng., etc.*) A small opening to allow the escape of air, where necessary, from some internal part of a machine or apparatus.

Air Lock (*Civil Eng.*) A chamber with doors at each end, one opening to the air, the other into a tunnel or other space filled with compressed air. Admission to the tunnel is gained through the air lock without the loss of pressure in the contained air which would occur if the tunnel were put into direct communication with the atmosphere.

Air Manometer (*Physics*). An instrument for measuring fluid pressure by means of the compression of air enclosed in a tube sealed at one end. The pressure is usually transmitted to the air by a column of mercury which fills the lower part of the tube, the other end of the column being exposed to the pressure to be measured.

Air Pumps. An air pump is an apparatus for "exhausting" or pumping out the air from any vessel, thereby producing what is called a "vacuum." No air pump really produces a vacuum in the strict sense of the word, inasmuch as there is always a certain quantity of air or other gas left in the space. The amount of this gas is best estimated by means of the pressure which it exerts on the walls of the vessel, the pressure being measured, as usual, in millimetres of mercury. A vacuum is required not only in a great number of chemical and physical experiments, but in various pieces of apparatus for the artificial production of cold, in tubes for Röntgen ray and other electrical work, and in the bulbs of incandescent lamps. Air pumps may be divided into two classes: MECHANICAL AIR PUMPS and MERCURY AIR PUMPS. The simplest form of mechanical pump is shown in fig. 1. A is a metal cylinder of smooth and uniform bore, in which a piston (B) is moved up and down by the piston rod C. B must fit the cylinder, or "barrel," as it is termed, as closely as possible, in order to be air tight. The tube D communicates with the vessel to be exhausted, and is closed at the top by a valve (E), consisting of a flap of oiled silk opening inward—*i.e.* towards the interior of the barrel. On raising the piston, air is drawn through the valve E into the barrel; when the piston is depressed, this air is forced out through the valve F in the piston, which is a similar valve to the one at E. The air which had been drawn into the barrel is thus expelled, and on raising the piston again, the valve F closes, and a further supply of air is drawn in through the tube D. This process goes on until a sufficient vacuum is obtained; but it cannot be carried beyond a certain degree of exhaustion, as the valves, being opened by the pressure of the air, will not work after the latter has fallen below a certain amount. Various attempts have been made to get over this difficulty with the valves by means of mechanical contrivances; but although it is possible to effect certain improvements by such means, no very high degree of efficiency has been reached. A great improvement in mechanical pumps has been made of recent years in what is called the FLEUSS PUMP. Fig. 2 shows the action of this pump in a diagrammatic manner. The barrel A has no valve at the foot, tubes E and F both opening into a tube (D) communicating with the vessel to be exhausted. The piston B is solid, and of such a thickness that when pushed nearly to the bottom of the cylinder, the pipe F is above its upper surface. The piston rod C passes through a cover (G), in which is a valve (H). This valve may be a comparatively heavy one, as it is not closed and opened by the pressure of the air. A layer of oil covers the top of the piston and the bottom of the barrel to the depth shown in the figure. On raising the piston, any air above it is driven out through H, and as the piston is raised, the oil above it gradually rises through the valve, completely expelling the air; when the piston falls again, the valve closes by its own weight, and a layer of oil which remains above the cover G effectually cuts off communication between the barrel and the outside air. When the piston again falls below F, air rushes through D, from the vessel which is being exhausted, into the barrel A, and is again expelled by the rising or up stroke. In this pump there is no valve whose opening depends upon the pressure of the inside air, and there is no space at the bottom of the barrel when the piston has completed its downstroke, so that the whole of the contained air is expelled. The efficiency of this pump is very great, and it is much used for the production of incandescent lamps; and, indeed, gives a sufficiently good vacuum for a great deal of vacuum tube work in electricity. The degree of exhaustion which is reached after a good number of strokes of a mechanical pump is given in the following calculation:

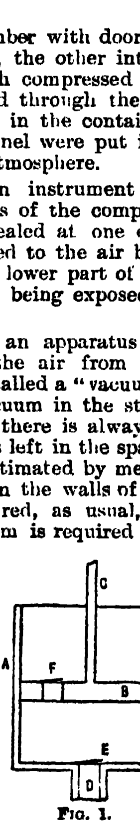


FIG. 1.

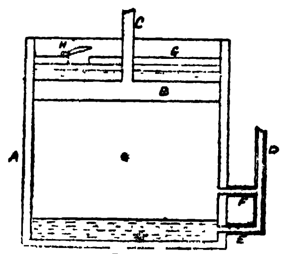


FIG. 2.

Let p = original pressure of the air.
V = volume of receiver and connecting pipes.
v = volume of the cylinder of the pump.

Then, in the first stroke, air which occupied a space V is caused to expand until it occupies a

space $V + v$. Then by Boyle's Law (*q.v.*) we get $pV = p_1 (V + v)$, where p_1 is the pressure after the first stroke is complete.

$$\therefore p_1 = p \frac{V}{V + v}$$

In the second stroke the air again expands from V to $V + v$, and its pressure falls from p_1 to p_2, where p_2 is the pressure after the second stroke is complete.

$$\therefore p_1 V = p_2 (V + v)$$

$$p_2 = p_1 \frac{V}{V + v} = p \left(\frac{V}{V + v}\right)^2$$

After the third stroke is complete we get a pressure $p_3 = p \left(\frac{V}{V + v}\right)^3$

After the n^{th} stroke,

$$p_n = p \left(\frac{V}{V + v}\right)^n$$

From this formula the pressure after any given number of strokes may be calculated.—**Mercury Pumps**: These depend in all cases on the production of the vacuum at the top of a barometer tube (*see* Barometers); but the manner in which this vacuum is utilised varies considerably in different forms of mercury pumps. Two of the main forms only will be described. The first of these is the Sprengel Pump (fig. 3). Mercury is poured into a large funnel (A), and flows through the tubes AB and BC into the "pump head" D, from which it falls down the "fall tube" DE, whose length is greater than the height of the barometer. The vessel to be exhausted communicates by means of the tube F with the tube bent at C. The mercury at first flows through DE in a nearly unbroken stream, but very rapidly breaks up into short threads of mercury with air between them, each thread acting as a kind of piston, expelling the air through the bottom of the tube DE, which dips into a suitable vessel where the mercury is collected. The action of this pump goes on continuously until the mercury in the funnel A has all flowed out. When this is the case, the action of the pump stops; but air cannot get into the tube F because a column of mercury rises in the tubes BC and ED, and as these are both longer than the barometer tube, the mercury in them cannot reach the top, and air cannot therefore get in. The Sprengel Pump will give a remarkably high vacuum, and its action, although somewhat slow, has the advantage of being very continuous. The second form is the Töpler Pump (fig. 4). In this pump a globe of fairly large capacity (A) communicates with the vessel to be exhausted by means of a tube (EF). B is a flexible tube longer than the barometer, at the end of which is a large mercury funnel (C). The latter is filled with mercury when in the position shown; it is then raised, and the mercury rises in the flexible tube B, flowing past a tube (E), and thereby cutting off communication between A and the vessel which is being

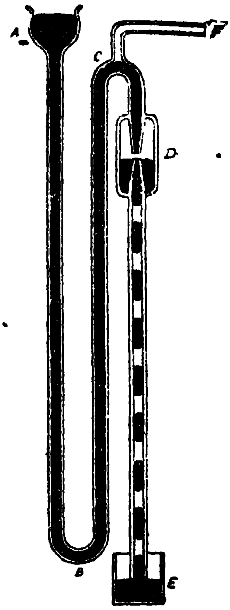


Fig. 3.

exhausted; and as C is further raised, the air is driven out of A through a tube (D), until at the end of the stroke a small quantity of mercury is also forced out of the top of A, and falls through D into a vessel placed to receive it. On lowering C, a vacuum is produced in A, and mercury rises in D. As the mercury falls below the level of the tube E, air rushes in from the vessel to be exhausted, and fills the globe A; this is again expelled at the next stroke. This process goes on until the height of the mercury column in D is practically equal to the height of the barometer, thereby showing that A and the vessel communicating with it are completely exhausted of air. In a good mercurial pump the pressure can be reduced to ·000012 of a millimetre of mercury, and in this case the height of a column, such as the one in the tube D, will be indistinguishable from the height of the barometer. The actual pressure of the contained gas must then be ascertained by some other means, such as a special form of pressure gauge known as the Macleod Gauge; or, if the vessel should be a vacuum tube, such as is used for electrical experiments, an electrical discharge passed through it will give a very good indication of the extent of the vacuum, as the electrical phenomena assume different appearances, corresponding in a well-marked manner to different degrees of exhaustion.—F. G. F.

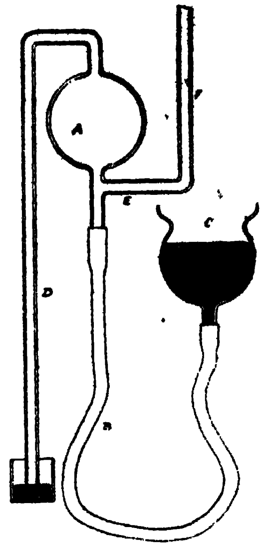


Fig. 4.

—— (*Eng.*) In engineering, a pump for removing the condensed steam, either alone or along with the water used to condense it, from the interior of the condenser into the air. This water cannot flow away by a simple opening, as there must be a partial vacuum continually maintained in the condenser, which any opening would destroy.

Air Receiver (*Eng.*) A vessel of considerable capacity sometimes placed between the blower and the furnace to render the pressure of the air more uniform.

Air Regenerator (*Eng.*) *See* Regenerator.

Air Spaces (*Eng.*) The gaps between the fire bars of a boiler.

Air Thermometer (*Heat*). An instrument for measuring a very wide range of temperatures by observing the change in pressure of a constant volume, or less frequently the change in volume at a constant pressure, of air enclosed in a suitable receptacle.

Air Vessel (*Eng.*) A vessel partly full of air, partly of a liquid, whose flow is rendered more uniform by the air above it acting as an elastic cushion, which neutralises the shocks of the pump and keeps the liquid flowing on between the strokes.

Aisle (*Architect.*) A lateral division of a church, separated from the nave or choir by columns or pillars. *See* Nave *and* Choir.

Alabaster (*Archæol.*) A small box or vase, originally made of alabaster, used for holding perfumes. There are specimens of great antiquity.

—— (*Min.*) A white granular variety of gypsum (*q.v.*); a hydrous sulphate of calcium, much used in the manufacture of plaster of Paris. This variety is chiefly found in England in the New Red Marls. Composition: $CaSO_4 . 2H_2O$. Also known as gypseous, or white, alabaster.

——, **Oriental** (*Min.*) A stalagmitic variety of calcite; of white or brownish concentric laminæ. Used as an ornamental stone under the name Algerian onyx.

Alanine, $CH_3CH . NH_2 . COOH$. α-amidopropionic acid. A decomposition product of albumin.

Alb (*Cost.*) A close-fitting ecclesiastical vestment, originally of fine linen, with apparels on the skirt before and behind, also on the cuffs.

Albertotype, Albert type, from name of inventor. A photographic plate so prepared that it can be printed from like a lithographic stone.

Albian Series (*Geol.*) A term often applied to the Gault, which English geologists regard as the lowest member in Britain of the Upper Cretaceous rock. The typical locality is near Folkestone; and the British rocks of this age mostly consist of clays of marine origin, ranging from 150 ft. to nearly double that thickness. These beds were formed in rather deep water. They afford remarkable illustrations of fossiliferous zones, in which the "zones" are mostly characterised by distinct species of organism, mostly Ammonites.

Albite (*Min.*) One of the rock-forming alkali silicates, constituting a soda felspar. Its composition, when it is quite pure, is $Na_2O = 11 \cdot 8$, $Al_2O_3 = 19 \cdot 5$, $SiO_2 = 68 \cdot 7$. Its crystalline system is anorthic. It is not uncommon as a constituent of the crystalline schists and gneisses. It sometimes occurs as a constituent within the body of granites and the rock allied to them; but more commonly it has been developed within drusy cavities in these rocks during the later stages of consolidation.

Albumen. Egg albumen, the white of the egg of the fowl (*Gallus banckivia*), is used in pharmacy and in photography. In the latter case it serves as the support or vehicle for the sensitive salts in printing papers of the older types.

—— (*Botany*). The tissue containing reserve food substances present in many seeds, and surrounding the embryo. It is also called endosperm—a preferable term, on account of the use of "albumen" for a definite chemical compound.

Albumin. A general term applied to those compounds containing carbon, hydrogen, nitrogen, oxygen, and sulphur, which form the most important constituents of living animals and plants, and give certain general reactions. They belong to the class of colloidal substances. They are coagulated on heating: precipitated from their solutions by alcohol and by certain salts, such as magnesium sulphate and ammonium sulphate: are generally amorphous solids, but some have been obtained crystallised—*e.g.* serum albumin: soluble in water, dilute acids, and alkalis: of unknown constitution. Hofmeister gives the formula $C_{450}H_{720}N_{116}S_6O_{140}$, corresponding to a molecular weight of 10166. Some of the general reactions referred to above are: (1) precipitation by the strong mineral acids; (2) precipitation by the alkaloid reagents; (3) the Biuret reaction (*q.v.*); (4) the xanthoproteic reaction (*q.v.*); (5) Millon's reagent (*q.v.*) Some of the decomposition products of albumins are glycocoll, leucine, aspartic acid, lysine, argenine, tyrosin, indole, skatole, and ptomaines (*q.v.*) For the classification of the albumins, consult a book on practical physiology. Ordinary white of egg is a typical albumin, and the name albumen is generally used for it.—W. H. H.

Albuminoids. These belong to the class of proximate principles which comprise the proteid group. They are derived from animals, are soluble in water, and contain the elements nitogren, carbon, oxygen, hydrogen, and sometimes sulphur. The albuminoids are of less nutritious value than the true proteids. At the same time, when mixed with proteids, they are of some value. In the group are gelatin, keratin, chondrin, and ossein.

Alburnum (*Botany*). The outer part (sapwood) of the wood of an old tree. It retains the power of carrying up the soil water absorbed by the roots.

Alcarraza (*Pot.*) An unglazed porous vessel for cooling water by evaporation, used largely in Spain, Egypt, and some parts of Asia.

Alcazar (*Architect.*) The Spanish name for a castle or palace.

Alcohol. This is a general term applied to any compound formed from a hydrocarbon by replacing one or more hydrogen atoms by the same number of hydroxyl (OH) groups, the hydrogen atoms replaced being attached to different carbon atoms. When only one hydrogen is replaced, we have a MONOHYDRIC ALCOHOL; when two are replaced, a DIHYDRIC ALCOHOL, and so on. There are three classes of alcohols: (1) PRIMARY, which have the formula $R - CH_2OH$, where R is a hydrogen atom or an alkyl radical (*q.v*); (2) SECONDARY, having the formula $\begin{matrix} R \\ R' \end{matrix}\!\!> CHOH$, where R and R′ are both alkyl radicals and which may be the same or different; (3) TERTIARY, having the formula

$$\begin{array}{c} R \\ | \\ R' - COH \\ | \\ R'' \end{array}$$

where R,R′,R″, are alkyl radicals which may be the same or different.

Examples:

$$\begin{array}{ccc} \begin{array}{c} CH_3 \\ | \\ CH_2OH \end{array} & \begin{array}{c} CH_2OH \\ | \\ CH_2OH \end{array} & \begin{array}{c} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} \end{array}$$

Monohydric alcohol from ethane C_2H_6. — Dihydric alcohol from ethane. — Trihydric alcohol from propane.

$$\begin{array}{ccc} \begin{array}{c} CH_3 \\ | \\ CH_2OH \end{array} & \begin{array}{c} CH_3 \\ | \\ CHOH \\ | \\ CH_3 \end{array} & \begin{array}{c} CH_3 \\ | \\ CH_3 - C . OH \\ | \\ C_2H_5 \end{array} \end{array}$$

Primary. — Secondary. — Tertiary.

Ordinary alcohol is ETHYL ALCOHOL, $CH_3 . CH_2OH$; it is produced by the fermentation of sugar. On the large scale it is obtained by allowing malt, which contains the enzyme diastase, to act in presence of warm water on barley and wheat. The diastase converts the starch of the grain into a sugar called maltose (*q.v.*) Yeast is added to the liquid, when the maltose is fermented, and yields alcohol. The WORT, as the product is called, is then submitted to steam distillation, when RECTIFIED SPIRIT is obtained, which is a mixture of alcohol and water, containing 84 per cent., by weight, of alcohol. To obtain ABSOLUTE ALCOHOL the rectified spirit is

allowed to stand over lumps of quicklime, and then distilled again. By repeating the process it can be obtained free from water. Alcohol is a faint, pleasant-smelling liquid, boiling at 76° C. It mixes with water in all proportions. On oxidation it yields first aldehyde (*q.v.*), then acetic acid. Alcohol enters into the composition of spirits, wines, and beers. Brandy, whisky, and rum contain about 50 per cent., gin 40, port wine 20, sherry 16, claret 7, and beer 5 per cent., by weight, of alcohol in every case. *See also* ETHYLATES, ETHYL CHLORIDE.—W. H. H.

Alcohol Fuel (*Motor Cars*). Alcohol, being volatile, readily forms a vapour, which, when mixed with air, is highly explosive. In France and Germany cheap alcohol, made from potatoes or beetroot, is utilised to a considerable extent in place of petrol.

Alcoholimetry (*Chem.*) The method of estimating the amount of alcohol in a liquor. If the liquor is a mixture of alcohol and water only, this may be done by taking the specific gravity and looking out the result in a table, or by use of a Sikes' hydrometer, which is an instrument specially devised for the purpose. In the case of beer, wine, etc., a suitable fraction is distilled, so as to obtain a mixture of alcohol and water only, and the amount of alcohol is estimated in the distilled part.

Alcove (*Building*). A vaulted recess: a niche.

Aldehyde. This is a general term applied to compounds containing the group R – CHO, where R may be hydrogen or an alkyl radical (*q.v.*), but is frequently used to denote acetaldehyde (*q.v.*) Aldehydes are generally liquids: easily oxidised to acids: readily polymerising (*q.v.*): combining directly with ammonia, prussic acid, and sodium hydrogen sulphite: with phosphorus pentachloride the oxygen is replaced by two chlorine atoms. They undergo condensation (*q.v.*) *See also* OXIMES *and* HYDRAZONES.

Alder, Common. *See* WOODS.

Aldol, $CH_3.CHOHCH_2CHO$. A liquid formed by the condensation of aldehyde.

Alençon Lace. This lace is manufactured by a process very similar to Brussels lace (*q.v.*) It is made in France, and, though very beautiful, is not equal to Brussels lace. In the modern Alençon, machine-made net is generally used.

Aleurone (*Botany*). The proteid (nitrogenous) grains found as a reserve material in cells, particularly those of many seeds. They are often of large size and complex character.

Al Fine (*Music*). To the end.

Algerian Onyx (*Min.*) *See* ALABASTER, ORIENTAL.

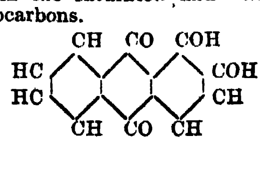
Alhambra (*Weaving*). A coarse counterpane or figured bed quilt with coloured threads, wrought by the Jacquard machine in large and ornamental designs.

Alignment (*Eng., etc.*) The correct placing in line of the parts of a machine or apparatus—*e.g.* the mandrel and loose centre of a lathe, or the front and back wheels of a bicycle.

Alinement, Alignment (*Archæol.*) Arrangement in lines. Stone avenues formed of *menhirs* or blocks of stone.

Aliphatic Compounds (*Chem.*) The compounds derived from the saturated and unsaturated open chain hydrocarbons.

Alizarin,



Orange-red needles which melt at 290°. It is found in combination as the glucoside ruberythric acid in madder root, from which it was formerly obtained. Now it is made from anthracene (*q.v.*), which, with fuming sulphuric acid, gives anthraquinone monosulphonic acid, and the latter on fusion with caustic soda and a little potassium chlorate gives sodium alizarin; addition of acid yields alizarin. It is a most important dye; with alumina as mordant, it gives *Turkey Red.* Many of its derivatives are also dyes—*e.g. Alizarin Blue,* which is used as a substitute for indigo, and is very stable. *See also* DYES AND DYEING.

Alkali. An alkali is a substance which yields, on solution in water, hydroxyl ions. Compounds such as caustic soda (NaOH), caustic potash (KOH), solution of ammonia (NH_4OH), slaked lime ($Ca(OH)_2$) can all evidently yield hydroxyl (OH) ions. Oxides, like quicklime, first form the hydroxide, *e.g.* $Ca(OH)_2$, and so on solution yield hydroxyl ions. In the case of salts of a weak acid, such as carbonic acid, which yields the alkali sodium carbonate, we have, on solution in water, the following change: $Na_2CO_3 + H_2O = NaHCO_3 + NaOH$, and in this case we again have hydroxyl ions. Alkalis have a caustic taste, turn red litmus blue, and neutralise acids, forming a salt and water. The alkalis ammonia, caustic soda and caustic potash, sodium and potassium carbonates, and quicklime (CaO) are prepared on an enormous scale. For the preparation of the first of these *see* AMMONIA: it was formerly, and is still sometimes, called the VOLATILE ALKALI, because it is readily volatilised on heating. Caustic soda and potash are often called the CAUSTIC ALKALIS, and their carbonates the MILD ALKALIS; these are all called *fixed alkalis,* because they are not readily volatilised on heating. SODIUM CARBONATE, Na_2CO_3, is prepared in two ways: (1) by the Leblanc Process; (2) by the Ammonia Soda or Solway Process.—THE LEBLANC PROCESS: Common salt is heated with oil of vitriol in iron pans; sodium hydrogen sulphate and hydrochloric acid gas are produced; the acid sulphate and the unchanged salt are heated in a reverberatory furnace, and give sodium sulphate and more hydrochloric acid gas. This is called the SALT CAKE PROCESS. The hydrochloric acid gas is passed into water, and the solution is commercial hydrochloric acid. The salt cake is now mixed with powdered coal and limestone ($CaCO_3$). The coal (C) reduces the sulphate to sulphide, and the latter, with the calcium carbonate, forms sodium carbonate and calcium sulphide. This product is called BLACK ASH from its colour. The black ash is now placed in tanks, and treated with warm water, which dissolves the sodium carbonate and leaves the calcium sulphide. This solution is called TANK LIQUOR, and the solid, ALKALI WASTE. Part of the tank liquor is used in making caustic soda (*see* below), while the alkali waste is used in the manufacture of sodium thiosulphate (*q.v.*) and treated for the recovery of the sulphur (*see* CHANCE'S PROCESS). For sodium carbonate the tank liquor is treated with carbon dioxide, obtained by heating limestone, and the liquid is crystallised, giving soda crystals ($Na_2CO_3 10H_2O$); on heating, these crystals lose their water and form SODA ASH—commercial sodium carbonate.—THE AMMONIA SODA PROCESS: Strong salt solution is saturated with ammonia gas, the liquid being cooled the while. The cooled solution is forced by compressed carbon dioxide into high towers, where it meets an ascending current of carbon dioxide, which is forced into the

bottom of the tower under pressure, the outside of the tower being cooled by a stream of cold water. Sodium bicarbonate separates as a solid, and ammonium chloride remains in solution. The bicarbonate is filtered off, washed, and heated, when it yields sodium carbonate and carbonic acid. The ammonium chloride solution is heated with slaked lime, and yields ammonia, which is used in the first stage of the process. The carbon dioxide from the bicarbonate, and that which escapes from the tower, carrying some ammonia with it, are collected and utilised again. This process is very economical, as the only waste product is calcium chloride; also it yields a purer product (98 to 99 per cent. Na_2CO_3). *See also under* SODIUM. CAUSTIC SODA, NaOH, is prepared from sodium carbonate solution (or from the tank liquor of the Leblanc Process) by mixing with milk of lime ($Ca(OH)_2$) and carefully heating; calcium carbonate separates, and a dilute solution of caustic soda results. This is concentrated in iron pans till it is of the requisite strength, and is then cast in moulds. *See also under* SODIUM. POTASSIUM CARBONATE, K_2CO_3, was formerly always obtained from the ash of plants, and some is still obtained from this source. The ash is treated with water and the clear solution evaporated in pots; hence the name POTASH. In repeating this process a purer product is obtained; it is called PEARL ASH. Most of the potassium carbonate of commerce is now obtained from the potassium chloride of the Stassfurt deposits by a process exactly similar to the Leblanc Process described above. CAUSTIC POTASH (KOH) is prepared from potassium carbonate, just as caustic soda is prepared from sodium carbonate. *See also under* POTASSIUM. Sodium carbonate is used on an enormous scale in making caustic soda, in making soluble glass (cement), in making sodium bicarbonate, and other sodium compounds. Caustic soda is used in soapmaking and in refining oils. Caustic potash is used in making soft soaps.—W. H. H.

Alkali Blue. *See* DYES AND DYEING.

Alkalimetry (*Chem.*) The process of estimating the amount of alkali in a substance by adding to a measured volume of its solution a known volume of a standard acid, and using an indicator to determine the neutral point. *See* INDICATORS.

Alkaline Development (*Photo.*) Development (*q.v.*) in which an alkali is added to the solution. It is most applied to the development of dry plates containing silver bromide, the alkali helping the separation of the bromine from the metallic silver which builds up the image.

Alkaline Earths. These are LIME, BARYTA, and STRONTIA.

Alkali Waste. *See* ALKALI.

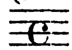
Alkaloid Reagents. Alkaloids give precipitates with: (1) Phosphomolybdic acid; (2) Phosphotungstic acid; (3) Iodine in potassium iodide; (4) Potassium mercuric iodide; (5) Potassium bismuth iodide; (6) Tannic acid; (7) Picric acid. The first three are the best and most delicate reagents. Picric acid does not give precipitates with all alkaloids.

Alkaloids are basic, nitrogen-containing ring compounds of vegetable origin; most of them are of unknown constitution, a few (conine, peperidine, nicotine, atropine) have a known constitution. Some are derivatives of pyridine, some of quinoline, and some of pyrrol. They have remarkable physiological action; most of them are optically active (lævorotatory), and some of them are among the most poisonous substances known. Besides those mentioned above, other important alkaloids are quinine, morphine, strychnine, cocaine, atropine, aconitine, veratrine, caffeine, etc.

Alkannin (*Botany*). *Alkannatinctoria* (order, *Boraginaceæ*). A red dye obtained from the root, and used in pharmacy and as a wood stain.

Alkyl. This name is given to the residue obtained by taking away one hydrogen atom from a molecule of a paraffin hydrocarbon. Thus, methane CH_4 yields the alkyl CH_3. They are not substances which can exist separately. CH_3Cl is an alkyl chloride, $(CH_3)_2Zn$ is a zinc alkyl; and so on.

Alla Breve (*Music*). In the time of a breve: four minims in a bar.

Alla Capella (*Music*). In church style: two minims in a bar, 

Allan's Link Motion (*Eng.*) A form of link motion (*q.v.*) in which a straight link is employed. In reversing, the eccentric rod is raised and the valve rod lowered by equal amounts (or *vice versâ*).

Alla Prima (*Paint.*) A painting executed without retouching. Rubens' pictures are notable examples of this method.

Allargando (*Music*). In a broad style: slackening the speed.

Allecret (*Cost.*) *See* HALECRET.

Allegory (*Art.*) A figurative representation: a symbol.

Allegretto (*Music*). Rather cheerfully: a diminutive of allegro.

Allegro (*Music*). Cheerfully, quick.

Allen's Governor (*Eng.*) A steam engine governor consisting of a fan revolving in a case filled with oil. The case can also move, but it does not do so as long as the speed of the fan is constant. When the latter varies, the case turns and acts on the regulating or throttle valve of the engine.

Allerions (*Her.*) Small birds without beaks and claws. Some hold that they are eagles which have lost beaks and claws.

Alligator Shears (*Metallurgy*). Large mechanically operated shears, with the lower blade fixed, used for cutting the bars of iron after puddling (*q.v.*) Also termed CROPPING SHEARS or CROCODILE SHEARS.

Alligator Squeezer (*Metallurgy*). A press worked on a lever principle for squeezing cinder and slag from puddled iron while still in a semi-fluid state. The name is derived from the large "teeth" or serrations on the jaws.

All Mine Pig Iron (*Metallurgy*). Ordinary pig iron, made entirely from ore, without admixture of iron-bearing slag. *See* CINDER PIG.

Allotropy. Many elements have the property of existing in more than one form. This phenomenon is called allotropy. Oxygen, O_2, exists in the *allotropic modification* ozone (O_3). Carbon exists as diamond, graphite, and charcoal. Phosphorus exists as yellow and red phosphorus. Evidently the physical properties of the allotropic modifications of an element are very different. The chemical properties are different in degree: thus, charcoal burns easily, diamond with difficulty.

Alloys. Alloys may be regarded as solid solutions of metals in metals. In some cases the metals in an alloy are in the ratio of their combining weights or multiples of these; then the alloy may be regarded as a definite compound. Alloys are produced: (1) by melting the metals together in proper proportions; (2) by electro-deposition—thus copper and zinc can be deposited together to form brass; (3) by compression of the finely divided metals. In practice metals are rarely used pure; a silver coin is an alloy of silver and copper, a gold coin of gold and silver, these alloys being harder than the pure metal.

Allspice (*Botany*). *Pimenta officinalis* (order, *Myrtaceæ*). The fruits, when nearly ripe, are dried in the sun, and form the allspice of commerce.

Alluvium (*Geol.*) Materials derived from the sub-aërial waste of upland areas are carried downhill and seawards by the action of running water. At those points where the velocity of the transporting agent, and therefore its transporting power, are checked, as where a stream reaches flat ground, or flows into a quiet pool or a lake, the materials previously carried forward by the running water are left, usually being spread out in thin layers. Accumulations thus formed soon grow up into dry land, and receive the above name.

Allyl. This is the name given to the group ($CH_2:CH.CH_2-$). $CH_2:CH.CH_2OH$ is allyl alcohol $= C_3H_5OH$. $CH_2:CH.CH_2I$ is allyl iodide $= C_3H_5I$.

Almandine (*Min.*) One of the Garnet group. It is much used in jewellery. Its colour is deep red, its hardness about 7. It crystallises in forms of the cubic system. In composition it is an iron aluminium orthosilicate. The chief localities are Ceylon (where it occurs in alluvial deposits, and *in situ* in gneiss), India, Brazil, Piedmont, etc.

Almandine Ruby (*Min.*) The violet variety of spinel (*q.v.*), cut and used as a gem.

Almayne Rivets, Almain Rivets (*Arm.*) Rivets which allowed the overlapping plates of armour to slide over one another; so called from their German origin.

Almond (*Botany*). *Prunus amygdalis* (order, *Rosaceæ*). Both the bitter and the sweet varieties yield the oil of almonds used in pharmacy.

—— (*Paint.*) An aureole, almond shaped, found in the works of early painters.

Almuce, Amess (*Cost.*) Not to be confounded with amice (*q.v.*) A fur hood or cape worn by ecclesiastics for the sake of warmth. It covered the shoulders, and hung down in front somewhat like a stole.

Aloes (*Botany*). *Aloe:* various species (order, *Liliaceæ*). This drug is prepared from the resinous juice of the leaves. Barbadoes aloes are derived from *A. vulgaris*; Socotrine aloes from *A. Perryi*; Curaçoa aloes from *A. chinensis*.

Alpaca. Wool of the Peruvian sheep or llama, of a soft lustrous fibre, used chiefly in the manufacture of dress fabrics known as alpacas.

Alps. A name originally applied solely to the upland areas of Switzerland and the mountain regions adjacent, but now extended so as to apply to any mountain tract of similar geographical character.

Al Segno (*Music*). To the sign 𝄋.

Alstonite (*Min.*) Barium calcium carbonate, $BaCO_3.CaCO_3$; barium carbonate $= 66{\cdot}3$; calcium carbonate $= 33{\cdot}7$ per cent. It crystallises in twins of the rhombic system; in appearance very like dogtooth crystals of calcite, but distinguished from calcite by the double striation on the crystal faces. From Alston Moor and Hexham.

Altar (*Archæol.*) The stand or table on which offerings to a deity were placed. In Christian times it is used to place the vessels on at the consecration of the elements. Originally of stone; now generally of wood.

Altar Cloth (*Dec.*) The covering of the Communion table or altar, often richly embroidered.

Altazimuth. An astronomical instrument for measuring the altitude and azimuth of heavenly bodies. Essentially a telescope capable of rotation round its horizontal and vertical axes, with graduated circles for measuring the angular movement in either plane. A smaller instrument on the same principle is used in surveying.

Alternate Continuous Transformers (*Elect. Eng.*) *See* ROTARY TRANSFORMERS.

Alternate Current. *See* ALTERNATING CURRENT.

Alternate Current Dynamos (*Elect. Eng.*) A dynamo without a commutator (*q.v.*) for rectifying the current, and therefore producing an alternating current (*q.v.*) *See* DYNAMOS.

Alternate Current Electro-Magnet (*Elect. Eng.*) A magnet (such as is used in alternate current arc lamps) worked by an alternating current. It must either be laminated or else built up of a bundle of iron wire, to reduce losses by induced currents.

Alternate Current Motors (*Elect. Eng.*) *See* MONOPHASE *and* POLYPHASE MOTORS.

Alternate Current Transformer (*Elect. Eng.*) *See* TRANSFORMER.

Alternating Circuit (*Elect. Eng.*) A circuit in which an alternating current (*q.v.*) is flowing. Calculations relating to these circuits must take account of their self induction (*q.v.*), and in many cases their capacity also, in addition to their resistance. The equations connecting the current and electro-motive force may be derived from Ohm's Law (*q.v.*) if we substitute impedance (*q.v.*) for resistance.

Alternating Current. An alternating current of electricity is, as its name implies, one that flows alternately in opposite directions. This does not mean that the current abruptly ceases and instantly flows in the opposite direction with the same strength. It commences at zero and rises to a maximum value, then falls to zero again and commences to flow in the opposite direction, again reaching a maximum and falling to zero; so that its value at any given instant would be represented by a wave-like curve which generally follows more or less closely the form of a "curve of sines" (*see* HARMONIC MOTION). The alternations are very rapid in most cases, about a hundred per second, and if we observe the filament of an electric incandescent lamp it appears to remain uniformly bright, just as it would if heated by a continuous current flowing steadily with a value of, roughly, three-quarters of the maximum strength of the alternating current. The special value of an alternating current is that we can take a small current with a very high voltage and transform it into a large current at low voltage by the use of a simple piece of apparatus called a transformer (*q.v.*), without any serious loss of power. As the transmission of a small current only requires the use of small wires in the mains, this method of distribution is very much

cheaper than the employment of a continuous current. For example, in lighting by incandescent lamps the voltage is about 100 volts in most cases, while the current supplied by the mains is at 2,000 volts, or twenty times as great a voltage; but the amount of current supplied by the mains in this case is only one-twentieth of the current after being transformed for use in the lamps—that is, if the mains were supplying 10 Ampères at 2,000 volts, the transformed current would give 200 Ampères at 100 volts (approximately). The chief disadvantage attending the use of alternating currents is that they are less suited for the driving of motors than continuous currents are; and when power has to be transmitted by their means, some special form of motor has to be used, and these forms can scarcely be said to have reached the same stage of efficiency which has been obtained by the continuous current motors.—G. F. G.

Altitude (*Astron.*) The angle between a star and the horizon, measured along a vertical circle.

Alto (*Music*). (1) The highest of the voices of men; also called counter-tenor. (2) The VIOLA (*q.v.* under MUSICAL INSTRUMENTS).

Alto-Relievo. Sculpture in which the figures project more than half their proper proportions from the background. *See* MEZZO-RELIEVO, BASSO-RELIEVO, CAVO-RELIEVO, *and* INTAGLIO.

Alum. Native potash alum (also called KALINITE) occurs in small quantity in the alum shales of Hurlet, near Glasgow, and at Whitby. It crystallises in octahedra of the cubic system. The composition of common alum is $K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$; but a number of other alums are recognised by chemists. These have the general formula $R_2SO_4M_2(SO_4)_3 24H_2O$, where R is *one* of the metals potassium (K), sodium (Na), or the group Ammonium (NH_4), and M is *one* of the metals aluminium (Al), chromium (Cr), or iron (Fe). Common alum is potassium aluminium alum, R=K and M=Al. It is made from aluminium sulphate (obtained from shale or bauxite) and potassium chloride and sulphate. It is used as a mordant in dyeing, as an astringent in medicine, and as an adulterant to whiten bread. ALUM IN BREAD: For the purpose of enabling inferior or damaged flour to be used in the making of bread, alum, in quantities ranging from 30 to 50 grains in a 4-lb. loaf, is added. It prevents fermentation, and tends to make the bread whiter. A good rough test for detecting the presence of alum is the logwood test (*q.v.*)

Alum Bath (*Photo.*) A solution of alum, which prevents gelatine films from "frilling," or curling up at the edges, when drying.

Alumina. Oxide of aluminium (Al_2O_3), a white amorphous substance the basis of alum, and the most abundant of the "earths." It is widely diffused over the globe, and is the chief constituent of all clays, the principal ingredient in the manufacture of porcelain, and is present in more or less quantities in glass. It is used extensively in the arts, and is valuable on account of its affinity for vegetable colouring matters and animal fibres. It forms the base of certain colours in dyeing, and also acts as a mordant. *See* ALUM, ALUMINIUM COMPOUNDS, POTTERY AND PORCELAIN, BRICKS, *etc.*

Aluminium, Al. Atomic Weight, 27. This metal occurs in clay, which may be regarded as chiefly aluminium silicate; in cryolite, which is a fluorine compound ($AlF_3 3NaF$.); in bauxite $(Al . Fe)_2O_3H_2O$; in felspars and china clay. It is now always obtained by heating aluminium oxide as pure as possible in an electric furnace. The furnace is an iron vessel lined with carbon, the vessel itself forming the kathode or negative pole; the anode consists of a number of carbon rods. The charge consists of the pure oxide alone or mixed with cryolite to serve as a flux. In starting the furnace the electrodes are brought together, and then the anode is gradually raised; the arc rapidly fuses the charge, and the metal begins to separate. The process is continuous. Very pure aluminium is obtained by heating the double bromide of aluminium and sodium with pure sodium. Aluminium is a greyish-white metal which melts at 654°; it is very malleable, and its conductivity for heat and electricity is about one-third that of silver; its tensile strength is about 12 tons per square inch. The metal *when pure* is quite permanent in air; it only oxidises at a very high temperature. Hot water slowly attacks it, forming the hydrate. Hydrochloric acid dissolves it; hot, strong sulphuric acid forms the sulphate, and nitric acid has very little action. Caustic soda solution readily dissolves it, evolving hydrogen and forming sodium aluminate, $3Na_2O, Al_2O_3$. Organic acids have no action except in the presence of common salt, when there is a slight action. Of its alloys, aluminium bronze, Al (10 parts), Cu (90 parts) is the most important; it is the strongest of the copper alloys, and has the colour of gold.

Aluminium Compounds. ALUMINIUM OXIDE, Al_2O_3, occurs naturally as CORUNDUM and with ferric oxide as EMERY; ruby, sapphire, and some other gems are aluminium oxide coloured by certain metallic oxides (Cr and Co). It is obtained by heating the hydroxide or ammonia alum, as a white powder insoluble in acids. ALUMINIUM HYDROXIDE, $Al_2(OH)_6$, is formed by adding an alkali to a solution of an aluminium salt. It combines with dyes forming coloured LAKES—hence the use of aluminium salts as mordants in dyeing. ALUMINIUM CHLORIDE, Al_2Cl_6: A hygroscopic white powder, formed by heating the metal in hydrochloric acid gas and by heating a mixture of the oxide and charcoal in chlorine gas. Forms double salts with the alkali chlorides, as Al_2Cl_6NaCl. Used as a condensing agent (*q.v.*) in organic chemistry. ALUMINIUM SULPHATE, $Al_2(SO_4)_3 18H_2O$: A white powder, formed by heating bauxite with sulphuric acid. Used in paper-making, in precipitating sewage, and in making alum.

Alum Leather. Leather dressed with alum and salt, either alone, for whips, aprons, etc.; or, for gloves, with alum, salt, flour, and egg yolk.

Alumstone (*Min.*) A hydrous sulphate of aluminium and potassium, $3(Al_2SO_6) . K_2SO_4 . 6H_2O$ · alumina=37·13, potash=11·34, sulphuric acid=38·53, water=13 per cent. Usually massive and granular, sometimes in rhombohedral crystals. It occurs in acid volcanic rocks near Rome, in Tuscany, Hungary, etc. It is an important source of alum.

Alunite (*Min.*) A synonym for alumstone (*q.v.*)

Alunogene (*Min.*) A hydrous aluminium sulphate, $Al_2SO_6 . 18H_2O$: alumina=15·4, sulphuric acid=36, water 48·6 per cent. It is a product of the decomposition of shales, containing pyrites (alum shales), and is source of alum. Its crystalline system is monosymmetric, but it usually occurs in fibrous veins and incrustations near Glasgow, Hungary, North and South America.

Amadou (*Botany*). *Polyporus fomentarius* (class, *Fungi*). A spongy form of tinder, made from a fungus on old trees by soaking thin slices in saltpetre solution.

Amalgam (*Chem.*) An alloy of mercury with another metal. TIN AMALGAM was formerly used in "silvering" mirrors and on the rubbers of frictional electric machines. SODIUM AMALGAM is used as a reducing agent, as it gives a slow stream of hydrogen when placed in water. GOLD AMALGAM is used in dentistry.

—— (*Min.*) A native amalgam of silver and mercury, $AgHg_2$: mercury = 65·2, silver = 34·8 per cent. In cubic crystals of brilliant tin-white colour; brittle. From Almaden, in Spain; Dauphiné, in France; Sala, in Sweden, etc. Another amalgam with more mercury is called ARQUERITE; it is ductile; it comes from Chili.

Amalgamation Processes (*Met.*) Both gold and silver can be extracted from their ores in certain cases by the treatment of the crushed ore with metallic mercury, thus forming a SILVER or GOLD AMALGAM. *See also* GOLD *and* SILVER.

Amassette (*Paint.*) A tool used in grinding colours to gather the material together, but, like the muller, it is now obsolete.

Amateur. One who has a taste for anything, but is not a skilled workman plying his trade for a living. The term is sometimes applied to one who is only a smatterer.

Amazons. Mythical race of female soldiers often represented in art—*e.g.* the strife between Theseus and the Amazons.

Amber (*Min.*) A fossil resin of light yellow to deep brown, washed up by the sea, chiefly on the shores of the Baltic; furnishes a valuable picture varnish; also much used for beads and pipe stems. The residue left when amber is heated is used in the manufacture of some fine black varnishes. Composition: carbon = 78·96, hydrogen = 10·51, oxygen = 10·52 per cent.

Ambergris. A substance formed in the intestines of the sperm whale (*Physeter macrocephalus*). It is found floating on the sea, and is much used in perfumery.

"**Ambitty**" (*Glass Manufac.*) A term used to denote that glass has become devitrified in the pot during the time it is being worked.

Ambo. A pulpit or reading-desk in an Early Christian church.

Amboyna Wood. *See* WOODS.

Ambulant (*Her.*) The action of walking.

Ambulatory. A part of a building intended for walking in, such as the cloisters (*q.v.*)

Amentum (*Botany*). A long hanging spike of unisexual flowers, such as one sees in the hazel or poplar.

American River Steamers (*Eng.*) Large steamers of very shallow draught, often propelled by a single paddle wheel fixed at the stern; hence called "STERN WHEEL" steamers.

Amethyst (*Min.*) A violet and transparent variety of quartz (*q.v.*) used largely for cutting as an ornamental stone. Its colour is due to traces of manganese. Found in Scotland, South America, China, etc. Amethyst was supposed by the ancients to protect against drunkenness. *See also* PRECIOUS STONES.

——, **Oriental** (*Min.*) A violet variety of corundum (*q.v.*)

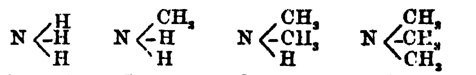
Amianthus (*Min.*) A very silky variety of asbestos (*q.v.*)

Amice (*Cost.*) "A fine piece of linen of an oblong square form, which was formerly worn on the head until the priest arrived before the altar, and then thrown upon the shoulders."—WAY. Often enriched by apparels.

Amides are compounds formed by the replacement of the hydroxyl of a carboxyl (COOH) group by the group NH_2. They are solids easily resolved into an acid and ammonia by boiling with dilute acid or alkali (*see* HYDROLYSIS). Dissolved in bromine and treated with caustic potash solution, they yield amines. Heated with phosphorus pentoxide, they yield nitriles. They are produced by heating the ammonium salts of organic acids; also by the action of ammonia on either an acid chloride (*q.v.*) or an ester (*q.v.*) For examples of amides, *see* ASPARAGINE *and* UREA, ACETAMIDE, BENZAMIDE.

Amido- *or* **Amino-.** These prefixes are employed to designate compounds formed by introducing a group NH_2 into a compound in place of a hydrogen atom—*e.g.* benzene is C_6H_6; the compound $C_6H_5NH_2$ is aminobenzene, commonly called aniline. The group NH_2 confers basic properties upon the compound formed by its introduction; thus aniline is a base. Many basic colouring matters owe their value as dyes to the presence of this group. Amino compounds have the group NH_2 replaced by OH when acted on by nitrous acids.

Amines. Compounds formed by the introduction of hydrocarbon residues into one or more molecules of ammonia in place of hydrogen. The amines are all bases like ammonia itself. *Monamines* are derived from one molecule of ammonia:



Ammonia. Primary amine. Secondary amine. Tertiary amine.

Diamines are derived from two molecules of ammonia:

A primary diamine. Ethylene diamine. A primary diamine. Phenylene diamine

Ammonia, NH_3. A colourless gas with characteristic smell; exceedingly soluble in water; it burns in oxygen, forming water and nitrogen. It is a powerful base, combining with all acids to form salts. It is used in the form of its aqueous solution. The strongest solution sold is called "880 ammonia," because its specific gravity is ·880. Ammonia is a constant product of the decomposition of nitrogenous organic matter. It is produced on the large scale from the ammoniacal liquor of the gasworks by boiling it with milk of lime.

Ammoniacal Gas Liquor. *See* GAS MANUFACTURE.

Ammoniacum. *Dorema ammoniacum* (order, *Umbelliferæ*). A medicinal gum resin which exudes from the stem of a Persian umbellifer.

Ammonia in Water. Ammonia in water in excess is taken as an index of pollution by fæcal or organic matter. Its presence either in a free state or as albuminoid ammonia is determined by quantitative analysis. For a qualitative examination Nessler's solution is added to the suspected water. If ammonia is present, the water will be coloured yellow.

Ammonia Soda Process. *See* ALKALI.

Ammonium. The name given to the group (NH_4), which is present in all ammonium salts. The group (NH_4) has no independent existence.

Ammonium Salts. AMMONIUM CHLORIDE, NH_4Cl: a white solid obtained when ammonia and hydrochloric acid are brought together: it is very soluble in water, and is used as a chemical reagent. Also called SAL AMMONIAC. AMMONIUM SULPHATE $(NH_4)_2SO_4$: formed by union of ammonia and sulphuric acid; a white solid, used as a manure. AMMONIUM CARBONATE, also called SAL VOLATILE. It is prepared by heating a mixture of ammonium sulphate and limestone. Ordinary ammonium carbonate is not a single substance, but a mixture of ammonium carbamate $CO < \begin{matrix} NH_2 \\ ONH_4 \end{matrix}$ and ammonium hydrogen carbonate $CO < \begin{matrix} OH \\ ONH_4 \end{matrix}$; when dissolved in water, it yields a solution of the latter compound. Ammonium salts are all decomposed when heated with a strong alkali such as lime or caustic soda, giving off ammonia. Most of the inorganic salts of ammonia sublime on heating.

Amœba (*Zoology*). A microscopic animal organism found in the mud of ponds and elsewhere. It is very simple in its structure, being merely a naked mass of protoplasm devoid of definite organs. Its shape is constantly changing, due to the constant flowing of the semi-fluid protoplasm.

Amorino (*generally in pl.*, **Amorini**). Cupids, often used for enrichment.

Amoroso (*Music*). Lovingly.

Amorphous. This term is applied to substances which have not a crystalline structure; *e.g.* amorphous carbon is that modification which is devoid of crystalline form—charcoal.

Amperage (*Elect. Eng.*) The amount of current which can be carried by a given conductor. It varies with the conditions of ventilation and other factors, which affect the cooling of the conductor. Tables showing the amount are given in electrical works.

Ampère (*Elect.*) The practical unit of electric current. It is one-tenth of the absolute unit (*q.v.*) Named after Ampère, a French electrician.

Ampère's Rule (*Elect.*) A rule for remembering the action of a current on a magnetic pole. If the observer swim with the current in the wire, and face the needle, then the north pole of the magnet will be deflected towards his left hand.

Ampères, Virtual (*Elect. Eng.*) *See* VIRTUAL CURRENT.

Ampère Turns (*Elect. Eng.*) The product of the number of turns in a coil and the number of Ampères flowing through it. *See* MAGNETO-MOTIVE FORCE.

Ampersand (*Typog.*) The name of the sign used for the word "and"—thus &.

Amphiantis. That form of Grecian temple which has a portico "in antis" (*q.v.*) at each end.

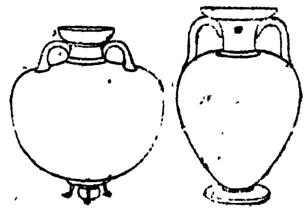
Amphibole (*Min.*) A general name applied to a section of the ferro-magnesian silicates which are allied in composition and crystalline characters to HORNBLENDE. They usually cleave in such a manner that two adjacent faces so formed give angles of about 56°. The crystallisation in tremolite, hornblende, and some other of less common occurrence is monosymmetric; in anthophyllite it is orthorhombic, while in ænigmatite it is anorthic. They are important members of the rock-forming silicates.

Amphibolite (*Geol.*) A rock consisting chiefly of one of the forms of Amphibole, usually that known as actinolite. It is generally more or less closely associated with gneiss, and is commonly one of the pegmatites of diorite gneiss. It often contains traces of some of the rarer elements.

Amphiprostyle. That form of Greek temple which has a columnar porch at each end only. *See* ANTA *and* PROSTYLE.

Amphitheatre. An elliptical or double theatre without a stage, but with a space—the arena—in the centre, and at a lower level than the first row of seats. *See* PODIUM.

Amphora. A large two-handled vessel, varying in shape, and either with or without a foot. That without a foot sometimes stood on a tripod. Amphoræ were common among the Greeks, Romans, and Egyptians, and were generally used for holding wine, oil, etc., though there are instances of their use as CINERARY URNS (*q.v.*) and even as coffins. They were generally made of earthenware; but there are numerous examples of amphoræ manufactured from more costly materials, elaborately decorated. The amphora was a standard measure with both the Greeks and Romans, among the former being equal to about 9 gallons and among the latter about 6 gallons.



AMPHORÆ.

Amplitude (*Phys.*) The amount which a vibrating body is displaced to either side from its position of rest—*e.g.* if a pendulum has a total swing of 10 in. from side to side, the amplitude, which is measured from the centre point of the path or position of rest, is 5 in.

Ampul, Ampulla. A small glass bottle, often two-handled; also the vessel containing the holy oil used in unction and in the consecration of kings.

Amulets. Charms, often of a grotesque character, still worn in some parts of the world, generally suspended from the neck. They sometimes consist of mystic words or characters, engraved on metals or stones. Such were those worn by the Early Christians.

Amygdalin. A glucoside (*q.v.*) occurring in bitter almonds and in kernels of apricots, cherries, and peaches. It is a white crystalline solid. It is resolved by the enzyme EMULSIN which is contained in almonds, and also by dilute hydrochloric acid, into glucose, prussic acid, and oil of bitter almonds:

$$\underset{\text{Amygdalin.}}{C_{20}H_{27}NO_{11}} + 2H_2O = \underset{\text{Glucose.}}{2C_6H_{12}O_6} + \underset{\text{Prussic acid.}}{HCN} + \underset{\text{Benzaldehyde (oil of bitter almonds).}}{C_6H_5CHO}$$

Amyl Acetate. A substance prepared by distilling a mixture of amyl alcohol, sulphuric acid, and sodium acetate. It is colourless, and possesses a smell like the essence of pears. Used in the preparation of collodion and other varnishes, and as a vehicle in many so-called gold paints.

Amyl Alcohol, $C_5H_{11}OH$. There are eight substances of this formula, but ordinary amyl alcohol is

a mixture of only two of them—*viz.* isobutyl carbinol $^{CH_3}_{CH_3}\!>CH\,.\,CH_2\,.\,CH_2OH$, the principal constituent, and active amyl alcohol $^{CH_3}_{C_2H_5}\!>CH\,.\,CH_2OH$. It is a peculiar-smelling liquid, and is lævorotatory. It is prepared from fusil oil by distillation, and is that fraction of the distillate which comes over about 132°.

Amyl Nitrite, $C_5H_{11}NO_2$. A pale yellow liquid smelling like peardrops. It is prepared by distilling amyl alcohol with nitric acid. When its vapour is inhaled it produces flushing of the face, and causes the heart to beat rapidly. It is used in chemistry in the preparation of diazo compounds.

Anærobic (*Botany*). The term applied to bacteria that cannot exist in the presence of oxygen.

Anaglyph (*Sculp.*) Ornament worked in low relief. *See* BAS RELIEF.

Anaglypta (*Dec.*) A relief decoration of hardened pulp formed in iron moulds. It is of great durability, and is made in a large number of artistic patterns for wall and ceiling decoration.

Analcime (*Min.*) A cubic zeolite; occurs in druses in volcanic rocks. Composition: $Al_2Si_3O_5 . Na_2SiO_3 . 2H_2O$: silica = 54·4, alumina = 23·3, soda = 14·1, water = 8·2 per cent. Found in many localities in Scotland, Giants' Causeway, Tyrol, Norway, Iceland, New Jersey, etc.

Analysis, Chemical. Is the name given to the processes employed in ascertaining the constituents of any substance. The analysis is said to be QUALITATIVE when the nature only of the constituents is ascertained, and QUANTITATIVE when the amount of the constituents is determined.

Anastatic Process (*Printing, etc.*) A method of facsimile reproduction from zinc plates, now superseded by lithography. *See* PROCESS WORK.

Anatase (*Min.*) An oxide of titanium, TiO_2: titanic acid = 98, ferric oxide = 2 per cent. (but variable). Tetragonal. Brown to deep dull blue. Cornwall and North Wales, Dauphiné in S.E. France.

Anatomy. The process and result of dissection of an organised body. Artistic anatomy comprises the knowledge of the structure and use of component parts of the human figure, more particularly the bones and muscles.

Ancaster Stone. *See* BUILDING STONES.

Anchor. A contrivance for mooring a vessel in a river or open sea; generally represented in art by the well known shape, with or without a cable. If the cable is twisted round the anchor, it is termed a foul anchor. The anchor is the emblem of hope.

Anchovy. *Engraulis encrassicholus* (family, *Clupeidæ*). A Mediterranean fish of the Herring family used as a food.

Ancon, *pl.* **Ancones** (*Architect.*) A console (*q.v.*), particularly when used to support the small cornice over a doorway.

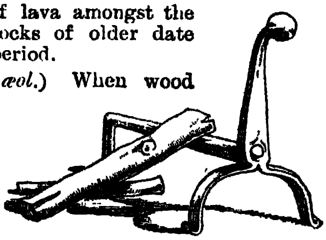
Andalusite (*Min.*) A rock-forming silicate which results from the thermo-metamorphism of rocks of argillaceous composition. It is chiefly allied to topaz, and is one of the trimorphous forms of crystallised silicate of alumina, whose other two are CYANITE and SILLIMANITE. One of its varieties is known as CHIASTOLITE. The composition of andalusite is $Al_2O_3 = 63$, $SiO_2 = 37$. Crystallisation, orthorhombic.

Andante (*Music*). "Going" at a moderate pace.

Andantino (*Music*). A diminutive of *andante*: going gently.

Andesine (*Min.*) A rock-forming silicate which constitutes one of the lime soda felspars. It is stated to be the predominating felspar in some of the lava flows of the Andes, whence the name. It is regarded as a mixture in about equal proportion of the soda, felspar albite, and the lime, soda anorthite.

Andesite. A name applied to an eruptive rock (usually a lava) which consists of a glassy or lithoidal ground mass, in which occur certain ferro-magnesian silicates, exclusive of olivine, and lime soda felspar (commonly labradorite), in larger proportion to the ferro-magnesian constituents than is the case in basalts. The composition is sub-basic, and the rocks weather with a lighter coloured crust than the basalts and their allies. It is the commonest type of lava amongst the British volcanic rocks of older date than the Tertiary period.



ANDIRON: ENGLISH, 18TH CENTURY.

Andirons (*Archæol.*) When wood was the common fuel, two iron (or other metal) supports, movable, were placed on either side of the open hearth. Against these the logs of wood leaned. Sometimes only one was used, in front, to support the spit.

Andrœcium (*Botany*). The term applied to the series of stamens in a flower.

Androsphinx (*Architect.*) A carved figure having the body of a lion and the head of a man. *See* SPHINX *and* KRIO-SPHINX.

Anelace, Anlace (*Archæol.*) A short sword or dagger, broad in the blade, sharpened both sides, and gradually narrowed from hilt to point. Seen on civilian monuments of thirteenth and fourteenth centuries. Also termed BASELARD.

Anemometer (*Meteo.*) An instrument intended for measuring the velocity of the wind. The ordinary form consists of four horizontal arms with hemispherical cups at the ends, the whole rotating on a vertical spindle, whose velocity is recorded by mechanism.

Anemophilous (*Botany*). The term describing those plants that are pollinated by means of the wind.

Aneroid (*Meteorol.*) A portable form of barometer which does not involve the use of a long column of fluid, hence it is suitable for determining the altitudes of mountains, etc. *See* BAROMETER

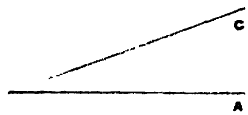
Angel Fish. *Squatina vulgaris* (family, *Squatinidæ*). A curious fish allied to the sharks and rays, formerly used as a food. The skin is used for polishing wood and also to form a fine shagreen.

Angelique. *See* WOODS.

Angiospermæ (*Botany*). One of the two great divisions of the *Phanerogamia* (flowering plants). The angiosperms are divided into monocotyledones and dicotyledones.

Angle. The degree of inclination of two lines to each other. A right angle is produced when one line meets another in such a way that the angles on both sides are equal. An acute angle is one less than a right angle; an obtuse angle is one greater than a right angle. A right angle may also be

defined as one subtended by a quadrant, or one quarter of a circle, whose centre is at the apex (or point) of the angle. In trigonometry it is often necessary to deal with angles which are greater than two right angles (180°). The definition of such angles is as follows: Let BC be a line which revolves about the point B, and originally coincided with the line BA. As BC revolves it is said to *describe* the angle ABC; thus in one revolution it will have described an angle of 360°, in two revolutions 720°, and so on.



Angle (*Lace Manufac.*) The inclination of the warp threads between the sley and the bars which gives the threads sufficient bias to keep them on the left or lower side of the hole or perforation through which they pass.

Angle Bead, *or* **Stuff Bead** (*Carp.*) A bead fixed to the external angle of a plastered wall to protect it. Modern practice is to run it in Keene's cement (*q.v. under article* CEMENTS). Also applied to a bead on an external angle in carpentry.

—— (*Plast.*) A bead run on the angle of a plastered wall.

Angle Bearing (*Eng.*) A plummer block (*q.v.*), in which the joint between the cap and main part of the block is at an angle with the base. Used when there is a thrust on the shaft which is not at right angles to the base of the block—*e.g.* in the crank shaft of an engine.

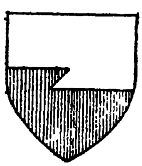
Angle Block (*Carp.*) A triangular block glued in an angle to secure two pieces together.

Angle Board (*Carp.*) A board on which wood is held in order that it may be planed with a certain angle (other than 90° or 180°) between two faces.

Angle Bracket (*Eng.*) A triangular frame of cast or wrought iron, used to stiffen the angles of a structure; in carpentry, a rough bracket fixed in the angle of a wall to support a cornice.

Angle, Critical (*Light*). *See* CRITICAL ANGLE.

Angled (*Her.*) A partition line rarely used on an English shield. The line is bent halfway and continued in a direction parallel to its original direction.


ANGLED (*Her.*)

Angle, Facial (*Art*). In tracing this the face is turned sideways, facing to right or left; a line is drawn horizontally through tip of nose, and another from the same point to front of forehead. The angle between these two lines is termed the facial angle. In antique statues the facial angle is generally about 90°.

Angle Iron (*Eng.*) A bar of wrought iron whose cross section has the form of the letter L. The angle is commonly, but not always, a right angle.

Angle of Advance (*Eng.*) The angle between the centre line of an eccentric sheave and the line which is at right angles to the crank. It causes the "lead" or opening of the port before the completion of the stroke of the piston.

Angle of Contact (*Eng.*) (1) With toothed wheels, the angle through which the wheel turns while two given teeth are in contact; (2) with belts, the angle subtended at the centre of a pulley by the part of the circumference in contact with the belt.

Angle of Contact (*Phys.*) The angle which the extreme edge of the surface of a fluid makes with a solid surface with which it is in contact. If the fluid can wet the surface (*e.g.*, water on perfectly clean glass), the angle of contact is 0°.

Angle of Deviation (*Light*). The angle between the directions of a ray before entering and after leaving a refracting medium—*i.e.* the angle through which the ray is turned or deviated by the medium.

Angle of Flexure (*Eng.*) (1) The angle through which one end of a shaft turns relatively to the other end when the shaft is subjected to torsion; (2) the angle through which any line in a body makes with its original direction when the body is subjected to torsion.

Angle of Friction (*Phys. and Eng.*) The angle at which a given plane surface must be inclined in order that a body may, when once set in motion, continue to slide upon it. In this case the force, acting on the body down the surface, equals the force of friction between the body and the plane. The tangent of the angle equals the coefficient of friction between the body and the plane surface.

Angle of Incidence (*Light*). The angle between a ray and the normal to the surface on which it is falling.

Angle of Inclination (*Eng.*) The angle which the thread of a screw makes with the axis.

Angle of Lag (*Elect. Eng.*) The difference of phase (*q.v.*) between an alternating electro-motive force and the current produced by it. The current always lags behind the E.M.F., reaching its maximum some time after the highest value of the E.M.F. has been passed. *See* POWER, ALTERNATING CURRENT.

Angle of Minimum Deviation (*Light*). The smallest angle through which a ray can be bent by a given prism. This minimum deviation is obtained when the entering and emerging rays make the same angle with the two faces of the prism.

Angle of Polarisation (*Light*). The angle at which a ray must be incident on a surface in order that the reflected ray may be polarised as completely as possible. *See* POLARISATION.

Angle of Reflection (*Light*). The angle between the reflected ray and the normal to the reflecting surface.

Angle of Refraction (*Light*). The angle between a ray after entering a refractive medium and the normal to the surface of the medium.

Angle of Relief (*Eng.*) The angle between the back edge of a tool and the material it is cutting. This angle prevents unnecessary friction between the tool and the material. It is greatest for soft materials, being between 20° and 30° for soft wood, down to 3° or 4° for hard metal.

Angle Plate (*Eng.*) A metal bracket, commonly right angled, for fixing work while being operated upon by machine tools.

Anglesite (*Min.*) Native sulphate of lead, $PbSO_4$: oxide of lead = 73·6, sulphuric acid = 26·4 per cent. It crystallises in forms of the rhombic system isomorphous with barytes, celestine, and anhydrite. It is named after Anglesea, where it was first found. It occasionally occurs massive. It is an oxidation product of galena. When in sufficient quantity, it is a valuable ore of lead. Anglesea, Cornwall, Cumberland, Dumfriesshire, Prussia, Siberia, Australia, United States.

Angle Tie (*Carp.*) A piece of timber connecting the wall plates across the angle of a building to receive the thrust of the hip rafter.

Anglo-Saxon Architecture. The name given to the architecture of England subsequent to the departure of the Romans, 449 A.D., and terminating with the Norman Conquest, 1066 A.D. The principal features of the work of this period are the belfry windows with baluster shafts, "long and short" work, triangular-headed openings, and pilaster and diagonal strips of worked stone in the rubble walls. *See* BALUSTER, "LONG AND SHORT" WORK, *and* ROMANESQUE.

Angora Goat. *Capra hircus* (family, *Bovidæ*). A variety of goat found in Asia Minor. It is valued on account of its hair, used in the manufacture of cloth.

Angular Acceleration (*Physics, etc.*) The rate of increase of angular velocity (*q.v.*)

Angular Capital. That form of Ionic capital in which a volute is placed under each angle of the abacus, and all the four faces are alike. *See* ARCHITECTURE, ORDERS OF.

Angular Diameter (*Astron.*) The angle subtended by the diameter of a heavenly body at the observer's eye.

Angular Displacement. The angle through which any given body has been turned.

Angular Distance of Stars (*Astron.*) The angle subtended at the observer by the arc of a circle drawn from one star to the other, and having its centre at the observer.

Angular Measurement. In ordinary cases this is in degrees (*q.v.*); in certain others it is given in circular measure (*q.v.*), which is better adapted to many mathematical calculations.

Angular Thread (*Eng.*) A screw thread whose section is triangular; the form most commonly used in ordinary screws.

Angular Velocity (*Physics, etc.*) The number of units of angular measurement through which an object turns in unit time. Thus, if a wheel make n revolutions per second, the angular velocity is $360n$ degrees per second, or $2\pi n$ radians per second.

Anhydride. The compound resulting when water is withdrawn from an acid. Thus, when nitric acid is distilled with phosphorus pentoxide, the latter withdraws water, and nitric anhydride results.

$$\begin{matrix} NO_2OH \\ NO_2OH \end{matrix} = \left.\begin{matrix} NO_2 \\ NO_2 \end{matrix}\right\rangle O + H_2O.$$

Anhydrite (*Min.*) An anhydrous sulphate of calcium, $CaSO_4$, $CaO = 41{\cdot}2$, $H_2SO_4 = 58{\cdot}8$ per cent., occurring in grey or white granular masses, sometimes in rhombic crystals. It is often found in association with gypsum, from which it is distinguished by its superior hardness, not scratched by the nail. Widely distributed.

Anhydrous. Without water; *e.g.* anhydrous ether means ether which has been freed from any water it might have contained.

Aniline, $C_6H_5NH_2$. A pale yellow liquid which turns red on keeping; boils at 183°; has a characteristic smell. It is a base. Slightly soluble in water. Prepared from nitrobenzene (*q.v.*) by reduction with tin (small scale), iron (on large scale), and hydrochloric acid; the product is made alkaline and distilled in steam. It gives a violet colour with bleaching powder solution, and a blue with potassium dichromate and sulphuric acid. It is used in preparing a large number of important dyes, hence the name "aniline dyes." *See* ROSANILINE, *also* DYES AND DYEING.

Aniline Dyes. *See* DYES AND DYEING.

Animal Charcoal. The product formed by distilling bones in absence of air. It only contains about 10 per cent. of carbon, the rest being calcium phosphate (80 per cent.), calcium carbonate, and other substances. Its most important property is its power of taking up colouring matter. In the sugar manufacture it is used to decolorise the syrup.

Animal Charcoal in Filters. Formerly considered an excellent medium for the filtration of water. Research has proved, however, that its use is accompanied with danger. To be efficient in their work, filters should sterilise the water—that is, they should free the water from all pathogenic organisms. Animal charcoal does not effect this; moreover, it adds to the water certain substances, phosphates and nitrates, which favour the growth and development of organisms. Its use should be discontinued in favour of the Pasteur-Chamberland or Berkefeld filter.

Animal Oils. *See* OILS.

Animal Refuse. *See* WASTE PRODUCTS.

Animals, Hybrid (*Myth.*) A compound animal made up from two or more species—*e.g.* a CENTAUR (*q.v.*)

Animation (*Art*). The touch of vivid life which a clever artist imparts to his pictures.

Animato / **Animando** } (*Music*). Animated.

Anime. A resin which exudes from a tree, called in the West Indies *Locust Tree.* It produces a fine varnish.

Anion (*Elect.*) A free atom, or group of atoms, in a solution, which travels towards the anode (*q.v.*) when the solution is subject to electrolysis. Thus, in a solution of a metallic salt, the group of elements left when the metallic element is taken away is the anion; *e.g.* in a solution of copper sulphate the anion is SO_4.

Anise. *Pimpinella anisum* (order, *Umbelliferæ*). The dried fruits form the aniseed used in pharmacy and as a flavouring agent. Oil of anise is distilled from the fruit.

Ankle Action (*Cycles*). The use of the ankle joint so that the foot acts on the pedal during a greater part of the downstroke, the pedal being, as it were, "clawed" round.

Anklet (*Archæol.*) An ankle ring of precious metal worn as an ornament by ancient races and by females of some Eastern races of the present day.

Annabergite (*Min.*) A hydrous arseniate of nickel, $Ni_3As_2O_8 . 8H_2O$. Monoclinic; occurring in capillary crystals, or as a pulverulent coating of Kupfernickel, from which it arises by decomposition; also colouring Kaolin in the proximity of nickel veins. Cornwall, Kirkcudbrightshire, Linlithgowshire, Annaberg in Saxony, the Harz, Thuringia, Sweden, etc.

Annatto. *Bixa orellana* (order. *Bixaceæ*). Annatto, or arnotto, is an orange dye obtained from the testa of the seed by soaking in water. It is used in varnishes, silk dyeing, colouring cheese and butter, etc.

Annealing. The process of strengthening a material by allowing it to cool slowly after heating. Metals, after much hammering or repeated shocks,

become brittle, and their toughness can generally be restored by annealing. Similarly glass, after being worked in a hot state, is very brittle, and requires annealing.

Annodated (*Her.*) Curved in the form of the letter S.

Annual Equation (*Astron.*) Fluctuations in the motion of the sun between perigee and apogee (*q.v.*)

Annual Rings (*Botany*). The circular marks seen in the cross section of a tree trunk, which show the amount of wood formed yearly, and also, therefore, the age of the tree.

Annular. Ring shaped.

Annular Gearing (*Eng.*) Tooth wheels, one of which has teeth on the inner side of the rim.

Annular Vault (*Building*). A vault having its abutments circular on plan.

Annulated, Annuly (*Her.*) A charge with an annulet or ring at each end,

Annulet (*Architect.*) A small fillet, the horizontal section of which is circular. There are usually from three to five annulets under the echinus or ovolo of a Doric capital. *See* DORIC *and* COLUMN.

—— (*Building*). A ring or fillet round a column.

—— (*Her.*) A plain ring which occurs as a charge, or on the shield of the fifth son as a mark of difference.

Anode (*Elect.*) The conductor or electrode by which a current enters a liquid.

Anomalistic Year (*Astron.*) The period of the revolution of the sun from perigee to perigee again.

Anorthic (*Min.*) One of the crystallographic systems (*q.v.*) in which there are three axes, all unequal and all inclined to one another at the origin at an angle other than a right angle Also called the Triclinic system. It has no plane of symmetry.

Anorthite (*Min.*) A somewhat rare rock-forming silicate, constituting a lime felspar. The chief mode of occurrence is that of one of the constituents (along with albite) of the intermediate types of the Plagioclase felspars. It occasionally occurs as a separate mineral, most generally in connection with the blocks of metamorphosed limestone formerly ejected from Vesuvius, and now to be obtained on Monte Somma.

Answer (*Music*). The response to the subject of a fugue.

Anta, *pl.* **Antæ** (*Architect.*) A pilaster used in Greek and Roman architecture as a finish to the side wall of a temple when it projected beyond the end wall. The capital and base of a Greek anta were always different from those of the columns used in conjunction with it. A temple is said to be "IN ANTIS" when its porch is formed by the projection of the side walls with two or more columns between them. This differs from a "PROSTYLE" temple, as in the latter the columns are placed in front of the antæ. *See* CELL, AMPHIANTIS, AMPHIPROSTYLE, PROSTYLE, *and* DISTYLE.

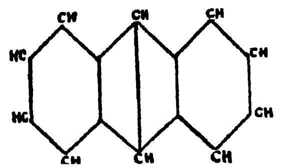
Antarctic Circle (*Astron.*) *See* ARCTIC CIRCLE.

Antefixæ (*Architect.*) Ornamental blocks, either of marble or terra-cotta, fixed along the eaves of a Greek building to cover the joints of the tiles.

Antependium (*Dec.*) Literally, anything hanging before the altar, now termed the frontal; generally an embroidered cloth.

Anthemion (*Architect.*) The honeysuckle ornament as used in Greek architecture, principally as an enrichment on a cyma-recta (*q.v.*)

Anthracene. Obtained from that part of coal tar which distils above 270°—"anthracene oil"—by a process too elaborate to be given here. It can be obtained synthetically—*e.g.* from benzene, acetylene tetrabromide, $C_2H_2Br_4$, and aluminium chloride. It is a white



ANTHRACENE.

crystalline solid, showing a blue fluorescence; melts at 213°. It is the parent substance of a large number of important dyes (*see* ANTHRAQUINONE *and* ALIZARIN). *See also* GAS MANUFACTURE, *and* DYES AND DYEING.

Anthracite. Hard coal, very rich in carbon, burning with an intense heat and little smoke; much used in steamships. *See also* COAL.

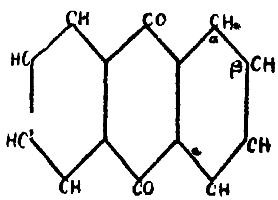
Anthranilic Acid (*O-amidobenzoic acid*),

$$C_6H_4 <^{COOH}_{NH_2} \ (1:2).$$

A white crystalline solid which melts at 145°; sweet taste. Obtained from indigo by the action of caustic potash. Used in the synthesis of acridine and quinoline derivatives, and now especially in the preparation of pure artificial indigo, for which purpose it is obtained cheaply from naphthalene (*q.v.*) *See also* PHTHALIC ACID *and* INDIGO.

Anthrapurpurin. *See* DYES AND DYEING.

Anthraquinone Crystallises in yellow needles which melt at 285°; it is produced by oxidising anthracene with chromic acid. Anthracene is formed from it by heating with zinc dust and ammonia. When anthracene is heated with fuming sulphuric acid, it gives β-anthraquinone sulphonic acid



—that is, the group SO_2OH replaces the H at β in the above formula. *See* ALIZARIN.

Anthropomorphism (*Myth.*) The representation of a god in the form of a man or woman.

Antichlor (*Chem.*) A substance used for removing the last traces of chlorine from materials which have been bleached by its means. The sodium sulphites and sodium thiosulphate are used as antichlors.

Anticlinal (*Geol.*) The sedimentary rocks composing the earth's crust have usually been deposited in horizontal layers piled one upon another. In some cases these have been left undisturbed, but in others the pile has been subjected to lateral thrusts which have bent the rocks into folds. It is convenient to distinguish these as downfolds or synclinals, and upfolds or anticlinals

Anticyclone (*Meteor.*) An area of high atmospheric pressure—*i.e.* one over which the barometer is high. Round this area the winds, observed from above, appear to be blowing in a clockwise direction.

Antifebrin. *See* ACETANILIDE.

Anti-Fouling Compositions. Substances used to prevent marine growths on the bottoms of ships.

They are very numerous; one is composed of zinc dust and mercuric oxide made into a paint.—HANNAY.

Anti-Friction Bearings (*Eng.*) The bearing or support of an axle in which friction is diminished by allowing the axle to rest on wheels, rollers, or spherical balls which can revolve. The ball bearings of cycles are a common example. *See* CYCLES.

Anti-Incrustators (*Eng.*) Substances used to prevent the formation of scale in boilers. Paraffin oil, peat, potatoes, and many other substances serve the purpose.

Antimonite (*Min.*) A synonym for STIBNITE (*q.v.*)

Antimony. This element occurs native as a tin white to dark grey lamellated or mammillated mineral; very brittle. It occurs in combination in Stibnite, Jamesonite, Boumonite, Kermesite, Valentinite, Senarmontite, etc. (*q.v.*) It occurs native at Allemont in France, in the Harz, in Bohemia, Sweden, Borneo, Canada, New York, etc. It is a metal of atomic weight 120, crystalline, brittle, easily oxidised; unacted on by hydrochloric acid. Hot strong sulphuric acid forms the sulphate $Sb_2(SO_4)_3$ and sulphur dioxide; nitric acid forms the pentoxide Sb_2O_5. The metal is obtained by heating the naturally occurring sulphide (stibnite) with iron and refining the product. It is used in making a number of alloys—*e.g.* type metal lead, 70; antimony, 18; tin, 10; copper, 2.

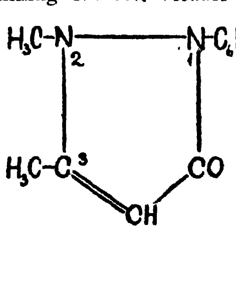
Antimony Compounds. OXIDES, Sb_2O_3, Sb_2O_4, Sb_2O_5. The trioxide Sb_2O_3, best prepared by adding water to solution of the trichloride and thorough washing of the precipitate of oxychloride, is used in making tartar emetic. Sb_2O_4 is formed when either of the other oxides is heated in air. Sb_2O_5 (*see* ANTIMONY). TRICHLORIDE, $SbCl_3$, formed by heating the sulphide with strong hydrochloric acid and evaporating to dryness, is a soft solid known as "butter of antimony"; mixed with olive oil, it is used in "bronzing" articles such as gun barrels. PENTACHLORIDE, $SbCl_5$, a liquid obtained by action of chlorine on antimony, serves as a chlorine carrier. SULPHIDE, Sb_2S_3: the natural variety is black and crystalline; the artificial variety, formed by passing sulphuretted hydrogen into solution of the chloride, is orange and amorphous; soluble in hot strong hydrochloric acid, forming the trichloride and sulphuretted hydrogen; soluble in alkalis and alkaline sulphides. Used in making safety matches and in pyrotechny.

Antimony Glance (*Min.*) A synonym for STIBNITE (*q.v.*)

Antiplastic (*Pot.*) Anything added to paste—*i.e.* prepared clay—to reduce its plasticity.

Anti-Priming Pipe (*Eng.*) A pipe which collects the steam from the top of a boiler and conveys it to the engine. It has a closed end, which is pierced with small holes; the object is to prevent fine spray (drops of water) from being carried over into the cylinder.

Antipyrine. Forms shining leaflets, soluble in water and alcohol; melts at 114°; a monacid base. Formed by heating the product of the reaction between ethylacetoacetate (*q.v.*) and phenylhydrazine (*q.v.*) with methyl iodide. Used in medicine as an antipyretic (lowering the temperature); it depresses the heart.



Antiquaille (*French*). Contemptuous term for antiquities of little importance.

Antiquarian. The name given to drawing-paper of size 53 × 31 in.

Antiquary. One who is devoted to archæology (*q.v.*), now generally termed an archæologist. Also applied to a dealer in curiosities.

Antique. In art, applied to ancient Greek and Roman works of art, especially those of the best and purest style. A course of drawing from the *antique* generally precedes drawing from the living model. A dealer in antiques is one who sells smaller relics of antiquity, as gems, etc.

—— (*Typog.*) Type in which all the lines of the face are of uniform thickness.

Antiquities. Remains or relics of ancient times, including monuments, arms, ornaments, customs, etc.

Antiseptics. Substances which prevent or arrest putrefaction by stopping the growth or destroying the organisms which induce it. Some of the most important are: mercuric chloride (1 in 1,000), carbolic acid, iodoform, chlorine, hypochlorous acid, boric acid, creosote, formaldehyde, etc. Antiseptics are frequently added to foods and to many organic materials used in the arts, *e.g.* size, for preventing mildew.

Anti-Syphonage Pipe (*Plumb.*) A pipe fixed to the top of traps to prevent the water seal (*q.v.*) being sucked out.

Anvil. The heavy block of wrought iron faced with hard steel on which metal work is hammered. Anvils range from the size used by watchmakers up to the huge masses, built up of many pieces, which form the support for forgings under the steam hammer. The name is also applied to parts of various machines.

Anvil Cutter *or* **Chisel** (*Eng.*) A short chisel, fixed by a shank into a hole in the anvil, across which a bar can be laid and cut by blows on the upper surface.

Aorta (*Biology*). The main arterial trunk given off from the heart.

A.P. (*Typog.*) These letters stand for "author's proof."

Apatite (*Min.*) A phosphate and chloride of calcium occurring in various shades of grey, green, and blue, granular or crystallised in hexagonal prisms. Composition: $3(Ca_3P_2O_8) . CaCl_2$.; lime = 48·43, phosphoric acid = 40·92, calcium chloride = 10·65 per cent. In some varieties fluorine replaces the chlorine. From Spain, Cornwall, Cumberland, United States, etc. COPROLITE is an impure variety of organic origin.

Aperture (*Photo.*) The area of the "stop" or opening through which the beam of light produced by the lens must pass. Decreasing the aperture diminishes the amount of light falling on the plate, and increases the time of exposure necessary, but it makes the image more sharp.

Apex. (1) The point or corner of a geometrical figure; (2) the summit of an object; (3) in mining, the part of a mineral vein which is nearest to the surface of the ground.

Apex Stone (*Building*). The stone at the top of a gable.

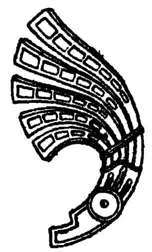
Aphelion (*Astron.*) The position of the earth when farthest from the sun—*i.e.* when the sun is at apogee. This occurs on the 1st of July. When the earth is nearest to the sun it is said to be in PERHELION, and the sun is said to be in PERIGEE. The diameter of the earth's orbit drawn between these two positions is termed the APSE LINE.

A Piacere (*Music*). At pleasure.

Aplite *or* **Haplite** (*Geol.*) A term now applied to a rock of eruptive origin which has been formed at a late period in the consolidation of an eruptive mass, usually one of plutonic origin. It represents the products of the magma, which were the last to consolidate, and which have filled cracks or other divisional planes in the cooling and contracting mass. Its constituents, in all cases, are of more acid composition than the mass in which it occurs. As examples, granite aplite, syenite aplite, diorite aplite, galbro aplite, etc.

Aplome (*Min.*) An iron calcium orthosilicate, one of the Garnet group. It is cubic, of deep brown, yellowish, or yellow green colour; hardness more than 7. Localities are the River Lena in Siberia, Ala in Piedmont, and Schwarzenberg in Saxony.

Aplustre. The stern of Greek and Roman galleys was continued upwards and shaped into an ornament so called. Used as an emblem of victory.


APLUSTRE.

A Poco a Poco (*Music*). By degrees.

Apogee (*Astron.*) The position of the sun, relative to the earth, when the distance between them has its greatest value. *See also* APSE.

Apollinaris Water. An alkaline spring water containing a large amount of sodium bicarbonate and smaller amounts of sodium chloride, potassium sulphate, and the bicarbonates of magnesium, calcium, and iron; it also contains dissolved carbonic acid.

Apollo. In Greek and Roman mythology the son of Zeus (Jupiter) and Leto (Latona). APOLLO BELVIDERE, a statue of Apollo in the Belvidere Gallery at the Vatican, esteemed one of the finest representations of the human figure extant.

Apophyge (*Architect.*) That part of a column between the cylindrical part of the shaft and the fillet of the base or of the necking. It is usually a cavetto, and is also known as the CONGÉ. *See* COLUMN.

Apophyllite (*Min.*) A tetragonal zeolite, colourless to greyish, often transparent. Composition: $K_2O . 8CaO . 16SiO_2 . 16H_2O$: silica = 55·5, lime = 23, potash = 4·8, water = 16·7 per cent. It often occurs in volcanic rocks with stilbite and other zeolites. Near Edinburgh, Talisku, Old Kilpatrick, Raith, in India at the Boorghat railway cutting, Greenland, Iceland, Norway, and Sweden.

Apostrophe (*Typog.*) The sign which marks the omission of a letter or letters; thus, *ne'er* for *never*; *can't* for *cannot*. In modern English it also indicates the possessive (genitive) case, *e.g.* the *boy's* hat.

Apotheosis. Elevation of a mortal to divine rank. In the case of Roman emperors this was effected by burning an effigy of the deceased; and as the fire ascended, an eagle was let loose, which was supposed to bear the soul aloft. There are in existence numerous representations of the ceremony in the form of medals, etc.

Apparels (*Cost.*) Richly embroidered cloth sewn on to the wrists of the alb and on the front and back of the lower edge; also on the amice. By some these five were considered to represent the five wounds of Christ. *See* ALB; AMICE.

Appassionata (*Music*). Impassioned.

Appaumée (*Her.*) The open hand with palm exposed to view.

Appearing (*Typog.*) A term used to express the length of the printed matter on a page, exclusive of whiteline.

Apple (*Botany*). *Prunus malus* (order, *Rosaceæ*). The well known fruit. In addition to its use for eating purposes, cider is made extensively from it in the west of England, Normandy, etc. In mythology, the Golden Apple, Apple of Discord, and other metaphorical references to the apple occur.

Apple Wood. *See* WOODS.

Appliqué. Ornament laid on or let into material; used of metal, wood, or textile fabrics.

Appoggiatura (*Music*). A leaning note. In performance it takes its value from the principal note which it adorns—*viz.* one half—unless the principal note is dotted, when it takes two-thirds of the value.

Approximation. A result or "answer" of some calculation or measurement which, though not actually correct, is near enough for the purpose required. Of great value in checking the correctness of a calculation.

Apricot. *Prunus armeniaca* (order, *Rosaceæ*). The tree is cultivated for its fruit. The liqueur *Eau de noyeaux* is distilled from the seeds.

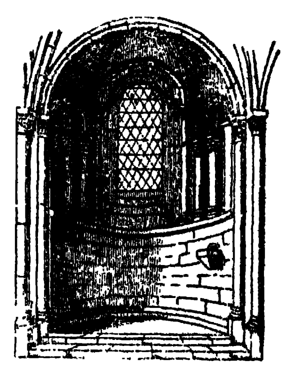
Apron (*Carp.*) A flat lining or covering used to protect parts of the structure underneath, especially the inside woodwork under a window.

—— (*Eng.*) The vertical front part of a screw-cutting slide rest; also applied to other machine tools.

—— (*Paper Manufac.*) A flexible rubber cloth used for guiding the pulp on to the machine wire.

—— (*Plumb.*) The horizontal flashing (*q.v.*) of a dormer, etc.

Apse (*Architect.*) A projecting portion of a building, semicircular or polygonal in plan; particularly applied to such a projection forming a termination to the choir, aisle, transept, or nave of a church. *See* BASILICA.


APSE, ROMSEY CHURCH, HANTS.

—— (*Astron.*) The points on the sun's orbit at which it is either nearest to the earth (perigee) or farthest away (apogee). The line joining the two apses is called the Apse Line.

Apse Line (*Astron.*) *See* APSE (*Astron.*)

A Punta d'Arco (*Music*). With the point of the bow.

Aquæ Manalis. The basin or dish in which the priest washes his fingers at celebration.

Aqua Fortis. Weak nitric acid used by etchers. The name was once universally used by chemists for nitric acid, whether dilute or not.

Aquamarine (*Min.*) The pale blue green variety of BERYL (*q.v.*) Aquamarine is cut as a gem.

Aqua Regia. A mixture of 3 volumes of hydrochloric acid and 1 volume of nitric acid. The mixture gives off chlorine and another gas called nitrosyl chloride, thus: $HNO_3 + 3HCl = 2H_2O + NOCl + Cl_2$. Called aqua regia by the alchemists because of its power of dissolving gold; the solution of the gold is effected by the chlorine which forms chloride of gold, a substance very soluble in water.

Aquarelle (*Paint.*) A painting executed with Chinese ink and very thin water colours.

Aquatint. *See* ENGRAVING *and* ETCHING.

Aqueduct. A conduit for conveying water from one place to another, extensively used by the Romans. Many of them still remain on the Continent, such as that at Segovia in Spain. The Claudian aqueduct, built A.D. 50, can still be traced. Ancient aqueducts were open at the top, and were built at a uniform gradient or slope, hence they were carried over valleys on lofty arches.

Aqueous Rocks. Rocks which have been formed by the direct action of water, as distinguished from rocks due to volcanic action, to the action of ice, to that of the wind, or to plutonic causes.

Arabesque. Ornament consisting of foliage, fanciful figures, flowers, fruit, etc., formed into scrollwork in flowing lines, either painted, inlaid, or executed in low relief. In Moorish arabesque or *Moresque* no animated life is depicted, being prohibited by their religion; but in the Renaissance work the human figure (or portions of the human figure), as well as animals, are introduced. Raphael's arabesques on the loggia of the Vatican are notable examples of the combination of allegory with ornament.

ARABESQUE, FROM ITALIAN MAJOLICA.

Arabinose, $CH_2OH \cdot CHOH \cdot CHOH \cdot CHOH \cdot CHO$. A sugar obtained by treating gum arabic or cherry tree gum with dilute sulphuric acid. It is crystalline, melts at 160°, and is dextrorotatory; not fermented by yeast. In other respects its reactions are like those of a sugar.

Aræostyle (*Architect.*) The name given to the spacing of columns in a Grecian temple when the space between the columns is equal to three and a half times the lower diameter of the shaft. *See* PYCNOSTYLE, SYSTYLE, EUSTYLE, DIASTYLE, *and* INTERCOLUMNIATION.

Aragonite (*Min.*) Calcium carbonate in the rhombic form (*see* CALCITE). Occurs in crystals, often twinned, and in fibrous and massive forms. Colour, when pure, white, but often coloured grey or green. Distinguished from calcite by its superior hardness and lack of cleavage. Composition: lime = 56, carbonic acid = 44 per cent. Occurs often in association with iron ores, also in vapour cavities in lavas.

Arbalest, Arbalist, Arblast; *also* **Arcubalist.** From the Latin *arcus*, bow, and *ballista*, an engine for throwing. A crossbow, especially those with mechanism for drawing the bowstring.

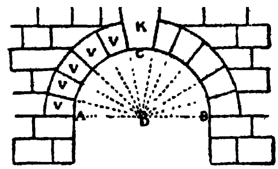
Arbor. The cylindrical axis of various parts of a timepiece — as BARREL ARBOR, FUSEE ARBOR, CENTRE ARBOR, etc.

Arbroath Flags. The grey micaceous flags which underlie the volcanic rocks of the Sidlaw Hills, and which form part of the lower division of the Caledonian (or "Lower") Old Red Sandstone. They are largely quarried for paving stones as well as for building purposes. It is mainly in this sub-division of the Scottish rocks of Devonian age that the remains of Pterygotus and of other allied Eurypterids have been found. Its relations to the rocks next beneath are not seen.

Arc. A part of the circumference of a circle; more generally a part of any curve.

Arcade (*Architect.*) A series of arches springing from pillars or columns, and used either for structural purposes or as a decorative treatment of a wall surface.

Arch. A curved structure built of separate blocks carrying the weight of a portion of a building over an open space. It therefore serves the same purpose as a beam (*q.v.*), but it does not require the use of one large piece of material the full width of the opening or span, and is consequently adapted to pure masonry work. The terms used with respect to arches will be readily understood by a reference to figure, which shows an elevation of one of the simplest forms, the semicircular arch. The line AB is termed the SPRINGING LINE, and its length the SPAN. The point C is the CROWN or VERTEX, and the height CD is the RISE. The inner curved line ACB is the INTRADOS, the outer curved line the EXTRADOS. The separate stones V, V are the VOUSSOIRS, the central stone K being termed the KEYSTONE, and the lowest ones at A and B the "SPRINGERS." The masonry which supports the arch on the two sides has various names; when it consists of vertical columns, the latter are called PIERS; if they have to resist an oblique thrust, as in most bridges, they are usually termed ABUTMENTS; if the arch rests on simple vertical walls, they are termed BEARING WALLS. The two halves AC and BC are termed the FLANKS or HAUNCHES. Besides being made in the form of an arc of a circle, arches are also built to various curves, such as the ellipse, parabola, hyperbola, and catenary; and they are also made with a pointed top for decorative purposes where great strength is not necessary. Among the latter are the Horseshoe Arch (Arabian work), Pointed (Middle Ages), Lancet (Gothic and Early English), Equilateral (Decorated), Ogee (Later Decorated), Segmental and Tudor (Debased Gothic). From the constructional point of view, arches are also classified as PLAIN, when made of unaltered bricks; GAUGED, when the bricks are accurately cut or rubbed to form the voussoirs; AXED or ROUGH ARCHES, when the bricks are roughly cut to the shape required. A SKEW ARCH is one which crosses a road, etc., at an angle: its plan is a rhombus or rhomboid, and the abutments must be cut stepwise to take the oblique thrust.



SEMICIRCULAR ARCH.

Archæan Rocks (*Geol.*) A term usually applied to the whole of the vast assemblage of rocks which are older than those of Cambrian age. It includes

the Lewisian gneiss and the ancient sediments associated with that complex mass. It probably includes also the greater part of the metamorphic schists which form the Scottish Highlands. The Archæan rocks of Britain are too varied in character to be adequately described in a short paragraph. The chief common characteristic lies in the fact that most of their structures are due to dynamic causes.

Archæology. The systematic study of all that appertains to past times, especially the remains and monuments of the prehistoric period.

Archaic. Pertaining to archaism.

Archaism. An imitation of what is old or obsolete, consequently out of character with its modern surroundings.

Archimedean Drill (*Eng.*) A small drill whose stock consists of a coarse screw thread, carrying a nut. By sliding the nut up and down, an alternating rotary motion is given to the drill. The drill must therefore be specially ground.

Archimedes' Principle (*Physics*). A solid immersed in a fluid experiences an upward force equal to the weight of the fluid displaced; the solid therefore appears to lose weight to an amount exactly equal to the weight of its own volume of the fluid.

Architectural Work in Photography. A lens is used which gives all lines as straight as possible; this requires some form of "doublet" lens (*q.v.*)

Architecture. The art of designing and constructing useful and beautiful buildings. It is generally divided into CIVIL (dealing with houses, bridges, and other buildings of ordinary utility), ECCLESIASTICAL (churches), NAVAL (ships), MILITARY (fortifications).

Architecture, Orders of. An architectural composition consisting of a column, with or without a pedestal, and with an entablature, is known as an order. Each of these three divisions of an order is again divided into three parts: the pedestal, consisting of a base, a die or dado, and a cornice or surbase; the column, of a base (excepting in the case of the Greek Doric), shaft, and capital; and the entablature, of an architrave, frieze, and cornice. There are three Grecian orders: the Doric, the Ionic, and the Corinthian. The Romans used these orders with various modifications, and also two varieties of the Doric and Corinthian, known as Tuscan and Composite respectively. Pedestals were introduced by the Romans with the object of increasing the total height of the order without altering the other dimensions (*see* GREEK ARCHITECTURE, ROMAN ARCHITECTURE, *and* PEDESTAL).—THE DORIC ORDER (*see illustration under* DORIC) is the earliest and most severe of the orders used by the Greeks. The chief buildings in which it is used are the Temple of Corinth (B.C. 650), the Temple of Theseus at Athens (B.C. 465), the Parthenon at Athens (B.C. 438), and the Propylœa at Athens (B.C. 437-2). The latter is partly Doric and partly Ionic. The column has no base, the shaft resting directly on the stylobate (*q.v.*) The shaft usually has twenty elliptical flutes meeting in arrises, and is worked to a very slight ENTASIS, the curvature in the case of the Parthenon shafts being about half an inch in a length of 31 ft. The upper diameter of the shaft is about four-fifths of the lower diameter. The height of the column varies from 4½ to 7, but is usually 6 times the lower diameter; the columns of the Parthenon are 5½ diameters in height. The capital is one of the most beautiful features of the order. Its height is usually equal to about half a lower diameter, and it consists of a neck separated from the shaft by a fine groove, a delicately moulded echinus with three to five fine armulets, and a perfectly plain abacus (*see illustration under* ABACUS). The height of the entablature is equal to about twice the lower diameter of the shaft, the cornice being about two-thirds the height of either the architrave or the frieze, and its projection being equal to about 1 module or half a lower diameter. The frieze is the most striking division of the entablature, consisting of square panels or metopes (*q.v.*) frequently carved, separated by the triglyphs, which are the constructive parts of the frieze. The face of each triglyph shows two vertical grooves and two chamfers or half grooves at the edges, the stop of the grooves at the top being usually curved (*see* TRIGLYPH). The band over the triglyph, known as its capital, has a much slighter projection than in the Roman examples. A triglyph occurs over each column with the exception of the end one, the triglyph in this case being placed at the end of the frieze. There is usually one triglyph over the space between any two columns, but occasionally the intercolumniation is increased so as to allow of two triglyphs in this position. Although the end triglyph is not placed over the centre of the end column, the two metopes nearest the end of the frieze are little, if any, larger than the others, as the end intercolumniation is reduced. The architrave projects slightly beyond the face of the shaft, and is very plain, having merely a tenia on its upper edge and a row of guttæ under each triglyph. It should be noted that the fillet over the guttæ and under the tenia, known as the capital of the guttæ, is rather deep, and that the guttæ are very short, the reverse being the case in Roman examples (*for illustration, see under* GUTTÆ). The cornice consists of a corona, on the sloping soffit of which is a series of mutules (*q.v.*), each mutule having three rows of guttæ on its underside, and a simple bed moulding. The crowning member of the cornice is usually an ovolo. In the Doric order of the Parthenon great care was taken to counteract optical illusions. The entasis of the shafts is just sufficient to prevent the appearance of hollowness which would be given by a simple conical form. An appearance of strength is imparted to the angles by reducing the end intercolumniation, and for similar reasons all the columns lean slightly inwards, and the stylobate and entablature are slightly raised in the centre. It should be noted that the effect of Greek Doric temples depended to a considerable extent on the colour decoration of their various parts.—THE ROMAN DORIC ORDER (*see illustration under* COLUMN) varies very considerably from that used by the Greeks. The column is usually 8 diameters in height, and has a base generally 1 module in height. The shaft is frequently not fluted, and its upper diameter is four-fifths or five-sixths the lower diameter. When the shaft is fluted, the flutes are semicircular in plan, and are separated by fillets. The capital is much less refined than that of the Greek Doric order. The necking consists of an astragal with a fillet and congé under, instead of the groove in the Greek Doric. The ovolo of the capital is a quarter circle, the annulets are rectangular fillets, and the abacus is crowned with a cymatium. The entablature (*q.v.*), like that of the Greek Doric, is 2 diameters in height, but the height of the architrave is reduced to about 1 module, the frieze—about 1½ modules in height—being made the largest member of the

entablature. The architrave does not project beyond the face of the shaft, but is in the same face as the neck of the capital. The end triglyph is always placed over the centre of the end column; the stop at the top of each groove or glyph is angular; the capital of the triglyph has a larger projection than in the Greek order; the guttæ on the architrave are longer than the Greek guttæ, but the capital of the guttæ is reduced in depth. Mutules are never used over the metopes, and are sometimes omitted altogether, and a dentil course substituted. The crowning member of the cornice is either a cavetto or a cyma-recta, instead of the ovolo used in the Greek Doric order.—THE GREEK IONIC ORDER (*see illustration under* IONIC *and* VOLUTE) is the second one used by the Greeks. Its proportions are more slender than those of the Greek Doric, and the mouldings are profusely enriched, carving taking the place of the colour decoration used with the Doric. The principal buildings in which it occurs are: The Temple on the Ilissus at Athens (B.C. 484); the Temple of Niké-Apteros at Athens (B.C. 469); the Propylæa at Athens – internal columns (B.C. 437-2); the Temple of Apollo Epicurius at Phigalæa—internal columns (B.C. 430); the Erectheum at Athens (B.C. 479-08); the Temple of Diana at Ephesus (B.C. 330); the Temple of Minerva Polias at Priene (B.C. 320). The details of the various Greek examples of the Ionic order vary much more than those of the Doric, but the following notes are of general application. The column consists of a shaft having twenty-four flutes, separated by fillets and descending into the congé; a base, usually richly moulded and generally of the Attic form, sometimes with and sometimes without a plinth; and a voluted capital. This capital consists of an enriched bead and echinus, both circular on plan, with a cushion-like feature above, the front and back faces of which are parallel to the wall of the temple. Each of these faces consists of a band terminating at each end in a volute. The projection of the echinus in front of this band is one of the two weak points in the design, the other being the difficulty which arises in the capital of a column at the angle of a building, the angle capital having a double face and the volute between the two faces being arranged at an angle of 45°. The abacus is much thinner than that used in the Doric order, and, unlike the latter, is moulded. The column varies from 8 to 9 diameters in height, the latter figure being the most usual proportion. The heights of the base and capital are about threequarters of a module and 1¼ modules respectively; the top diameter of the shaft is about 1⅝ modules. The entablature is generally 2 diameters in height, and the three divisions of it are about equal. The architrave usually has three fascias, each of the upper two of which projects slightly beyond the one beneath it, and is finished with a delicate cymatium. The frieze is either quite plain or is sculptured in relief. The cornice usually has a dentil course below the corona, and the latter is generally finished with an enriched cyma-recta.—THE ROMAN IONIC ORDER: There is not so much difference between the Greek and Roman examples of this as there is between those of the Doric and Corinthian orders. Like the Doric order, however, it was little used by the Romans. In the Roman Ionic order the column is 9 diameters in height, the shaft being either plain or fluted. The base is usually of the Attic form, and always has a plinth. The capital is often made with angle volutes, the four faces being similar, and the abacus concave on plan. When this is done, the scrolls spring out of the echinus, and do not form an integral part of the capital, as in the Greek order. The entablature does not differ much from that of the Greek Ionic, with the exception, of course, of the detail of the mouldings and their enrichments.—THE GREEK CORINTHIAN ORDER: The Corinthian order was little used by the Greeks, the principal examples being the Choragic monument of Lysicrates at Athens (B.C. 335) and the Tower of the Winds at Athens (B.C. 100-35). The shaft and base are only slightly different from those used in the Greek Ionic order, but the shaft is generally 10 diameters in height. The Corinthian order at the Tower of the Winds has no base, and there is no plinth to the base of the other example mentioned. The capital is again the most distinctive feature of the order, and in the case of the Choragic monument of Lysicrates is 1½ diameters in height, and consists of a bell-shaped core, the lower part of which is clothed with a conventional treatment of the acanthus leaf, the upper part having a small volute at each of the four angles with honeysuckle ornament between, and a moulded abacus with concave faces.—THE ROMAN CORINTHIAN ORDER (*see illustration under* CORINTHIAN). The Corinthian order was more fully developed by the Romans, and was the one principally used by them. The column varies from 9½ to 10½ diameters in height, and generally has a base resembling the Attic. The shaft is generally fluted, but sometimes the upper part is fluted and the lower part plain. The capital, about 1⅙ diameters in height, is richly carved, even the mouldings of the abacus being enriched in some cases. It consists of two tiers of acanthus leaves at the base of the bell, four pairs of large volutes supporting the angle of the abacus, and four pairs of small volutes under the flowers or "roses" in the centres of the concave faces of the abacus. The entablature is about 2½ diameters in height, the heights of the frieze and architrave being about equal, and each rather less than the height of the cornice. The principal feature of the entablature is the use of modillions above the dentil course to support the corona of the cornice. These modillions, and almost all of the mouldings of the entablature, are richly carved. The projection of the cornice is about equal to its height. The frieze is frequently quite plain, but the architrave, which consists of three fascias and a crowning moulding, is usually enriched.—THE TUSCAN ORDER (*for illustration, see* TUSCAN) is a Roman modification of the Doric order. It is the simplest of the orders used by the Romans, being always used without enrichment. The column is usually 6 diameters in height. The capital is similar to the Roman Doric, but the abacus has merely a fillet at its upper edge in lieu of the moulded Doric cymatium; the shaft is never fluted, and the base consists of a fillet, a torus, and a plinth. The entablature is rather less than 2 diameters in height, and is perfectly plain, having neither triglyphs, mutules, dentils, nor modillions. The crowning moulding of the architrave is simply a small cavetto and a fillet.—THE COMPOSITE ORDER (*for illustration, see* COMPOSITE) is a modification of the Corinthian order, and was not used by the Greeks. The chief alteration is in the capital, the upper part of which is similar to the Roman Ionic capital, with angle volutes, while the lower is very similar to that of the Roman Corinthian capital. The general proportions are the same as those of the Roman Corinthian order. The term ORDERS is also used to denote the recesses or groups of buildings in a Gothic or Romanesque arch.—W. S. P.

Architecture, Styles of. *See* BYZANTINE, INDIAN, ITALIAN, POINTED, GOTHIC, ANGLO-SAXON, NORMAN, EARLY ENGLISH, TUDOR, ELIZABETHAN, STUART, *and* RENAISSANCE STYLES.

Architrave (*Architect.*) The lowest of the three chief members of an entablature. It is the main beam, and rests directly on the columns. It is also known as the EPISTYLE. The term ARCHITRAVE is also used to denote the moulding bounding the head and sides of a door or window opening. *See* ARCHITECTURE, ORDERS OF, ENTABLATURE, *and* COLUMN.

Architrave Block (*Carp., etc.*) The block at the bottom of the architrave moulding around a door opening into which the skirting is fitted or "finished."

Archivolt (*Architect.*) The mouldings on the face, and following the curve, of an arch.

Arc Lamp (*Elect. Eng.*) A pair of carbon rods connected to a current of sufficiently high voltage to produce an electric arc between the poles or ends of the carbons. This requires about 50 volts continuous or 33 volts with an alternating current. The carbons are connected to mechanism worked by the current which brings them together when the current is first turned on, then separates them a short distance (thus "striking" or setting up the arc), and then "feeds" the carbons or brings them up to a constant distance as they are burnt away. The chief differences between lamps consist in the nature of the mechanism employed for this purpose.

Arco (*Music*). With the bow; used after *pizzicato*.

Arctic. A general term applied (1) to organisms which resemble or are connected with those which live in the circumpolar regions; (2) to climatic or other geographical conditions resembling those found in those regions; or (3) to strata which have been formed in the same manner as those occurring in the Arctic regions.

Arctic and Antarctic Zones (*Astron.*). The part of the earth's surface lying between the Arctic or Antarctic Circles, and the respective poles.

Arctic Circle (*Astron.*) A circle or parallel of latitude, north of which the sun remains above the horizon for twenty-four consecutive hours during some portion of the year. This latitude is 66° 32′ 30″. The corresponding south latitude is called the Antarctic Circle.

Are. *See* WEIGHTS AND MEASURES.

Area. The amount or measure of a surface. *See* WEIGHTS AND MEASURES).

——, **Dry** (*Building*). In order to prevent dampness in the floors and walls of houses with basements, a "dry area" is constructed. A space is left all round the basement, of sufficient width to keep the damp soil from the walls. This is covered at the top, except in certain places where openings are left for ventilation. The drainage of the area requires particular attention.

Areal Velocity (*Astron., etc.*). The area swept out in unit time by the line joining a planet to the earth. Kepler's Second Law states that this areal velocity is a constant for any given planet.

Areas. *See* SANITATION—DWELLINGS.

Areca Nut. *Areca catechu* (order, *Palmæ*). The seeds are used in pharmacy, and in the East for chewing.

Arenaceous Rocks (*Geol.*) Sedimentary rocks of derivative origin, which consist essentially of grains of sand. They include not only sand, but also sandstone, quartzile, and grey wacké. They are simply aggregations of particles of quartz, which have been derived from the waste of some pre-existent rock containing that mineral. Arenaceous rocks are specially characteristic of rocks of terrigenous origin, and rarely or never enter into the composition of those formed in the deep sea.

Arenig Beds (*Geol.*) Strata of Lower Ordovician age, which are on the same geological horizon as those which form the Arenig Mountains in Wales. They differ much in mineral character in different parts of Britain, consisting largely of volcanic materials in Wales and the north-west of England, of deep sea radiolarian oozes in the south of Scotland, and probably of limestone in the north-west. They contain a characteristic suite of graptolites and trilobites in the area where they consist of argillacean sediments.

Argal *or* **Argol**. The reddish-brown crust which forms when wine is kept in bottles or casks. It is impure acid potassium tartrate (cream of tartar), and constitutes the source of tartaric acid (*q.v.*) and its salts.

Argand Burner. The name was originally applied to an oil burner having a wick enclosed between two concentric tubes. The burner is now used extensively for burning gas, and consists of a hollow ring, through the upper surface of which the gas issues by a number of small holes. To protect the flame a glass chimney is provided, by which also the entrance of air is regulated. *See also* ARTIFICIAL ILLUMINANTS.

Argent (*Her.*) Silver: usually contracted to *ar*: on a shield it is shown blank.

Argentic. *See* ARGENTUM.

Argentite (*Min.*) Sulphide of silver, Ag_2S: silver = 87·1, sulphur = 12·9 per cent. Occurs in cubic crystals of a black lead grey colour: very similar to galena, from which it is distinguished roughly by being sectile. Nearly all galena contains some silver, which probably exists as the isomorphous sulphide argentite. From Cornwall, Norway, Bohemia, Saxony, Mexico, Chili, Peru, and many localities in North America.

Argentum. The Latin name for silver. From this word the symbol Ag for silver is derived, also the word argentic, which is applied to the silver salts—*e.g.* argentic nitrate is silver nitrate.

Argillaceous (*Geol.*) Claylike: containing clay.

Argillaceous Rocks (*Geol.*) Strata consisting essentially of clay, and thus always primarily of derivative and sedimentary origin. Mud, clay, mudstone, shale, marl, argillite, and Lydian stone are amongst their varieties. Many (but by no means all) slates are also of argillaceous composition, as also are the dynamically metamorphosed rocks known as phyllites.

Argillite (*Geol.*). A name restricted to rocks of argillaceous composition and sedimentary origin, which have been much indurated by pressure and other causes, but which have not been affected by cleavage (*see* SLATES), nor by dynamic metamorphism (*see* PHYLLITE), nor by thermo-metamorphism (*see* LYDIAN STONE, JASPER etc.) The arenaceous associate of argillite is usually GREY WACKÉ (*q.v.*)

Argon. A gas forming rather less than 1 per cent. of the atmosphere. Its presence in the air was first

indicated by the fact that a litre of nitrogen prepared from air was found to weigh heavier than a litre of pure nitrogen obtained in other ways. It can be obtained by passing electric sparks through air in presence of caustic potash, and gradually adding oxygen till all the nitrogen has been converted into potassium nitrite and nitrate. Atomic weight, 40. Has a characteristic spectrum, a monatomic molecule (*q.v.*) It appears to be incapable of entering into chemical combination with any other element or compound whatever.

Aries, First Point of (*Astron.*) The point of intersection of the celestial equator and ecliptic, through which the sun passes as it crosses from south to north of the equator.

Aril (*Botany*). An outgrowth upon the seed coat or testa, either as an investment or as an excrescence. The mace of the nutmeg and the fleshy cup of the yew fruit are examples.

Arkose (*Geol.*) A name originally applied to any conglomerate which contained felspar fragments, whether decomposed or not; but now restricted to derivative rocks which have been formed under arid conditions and in which the parent rock has been a granite or a gneiss. Arkose thus differs from a conglomerate in containing, along with quartz or other mineral fragments, pieces of *undecomposed* felspar. A typical arkose occurs abundantly in the Torridon sandstone. It is also found in the Old Red.

Armature (*Architect.*) A term used for bars of iron added to various parts of architectural structures to strengthen them without detriment to the decorative effect of which they form a part—*e.g.* iron cross bars in a leaded window.

—— (*Elect. Eng.*) (1) The piece of soft iron which is placed in contact with the poles of a permanent magnet to aid in retaining the magnetic lines; (2) a piece of soft iron on which the magnet acts by magnetic attraction in order to actuate some piece of electrical apparatus, such as a relay (*q.v.*); (3) the rotating portion of a dynamo or electric motor. *See* ARMATURES.

Armature Binding (*Elect. Eng.*) Strips of thin metal or wire bands which hold the windings close to the iron core.

Armatures of Dynamos. An armature is the portion of the dynamo in which the current is actually produced. It usually consists of coils of wire rotating in the strong magnetic field between the poles of the magnets. This rotation produces a continuous variation in the number of lines of force which pass through each coil of the armature, and therefore a current is caused to flow through these coils. The current is led from each coil to the corresponding bars of the commutator, and is collected by means of brushes. In the majority of cases the coils are carried on a cylindrical core of soft iron, which serves the double purpose of acting as a support to the windings and also of concentrating the lines of force between the poles, and causing them to pass through the coils of the armature.

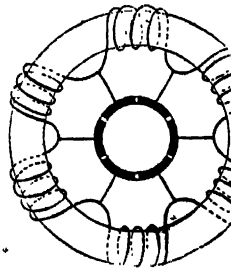


FIG. 1.

Armatures may be divided into four main types: (1) RING ARMATURES: A typical ring armature is shown in fig. 1 in a diagrammatic form. In this case there are six coils wound on an iron ring, the beginning of one coil being connected to the end of the preceding one, and the point of junction being also connected to a bar of the commutator, which is shown in black shading in the diagram. As each coil passes through what is termed the "neutral point"—that is, the position in which the current in it becomes reversed —the commutator bar to which it is connected passes from contact with one brush to contact with the next, and by this means the current in the external circuit is kept flowing in the same direction. The essential point to notice about a ring armature is that the windings pass over the external surface of the iron core, and return through the inside of the core.

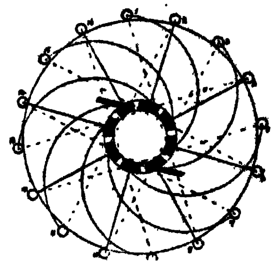


FIG. 2.

(2) DRUM ARMATURES: This is the form chiefly used in large continuous current machines. In this case the windings are all external to the iron core. The method of connecting the windings is varied and complex. One method is shown in fig. 2. In this case sixteen conductors, numbered 1 to 16, are shown on the outside of the armature. The method of connecting them at the end of the armature nearest the commutator is shown by continuous lines, and the connections at the farther end are shown by dotted lines. It will be seen that conductor No. 1 is connected at the back of the armature to No. 8, No. 3 is connected to No. 10, No. 5 to No. 12, and so on.

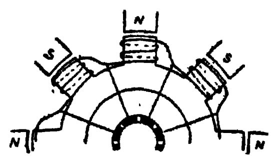


FIG. 3.

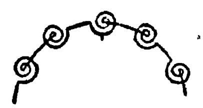


FIG. 4.

(3) POLE ARMATURES: This form is shown in fig. 3. It is very frequently used in alternate current machines, where field magnets with a large number of poles are employed.

(4) DISC ARMATURES: These are armatures where the wire is wound into flat coils of spiral or similar form. In this case there is no iron inside the coil of the armature; but the coil is made very thin, and very nearly occupies the whole of a very narrow gap between each pair of poles of the field magnets. The winding of a disc armature is shewn diagrammatically in fig. 4, and the form actually taken by the coils in fig. 5.—G. F. G.

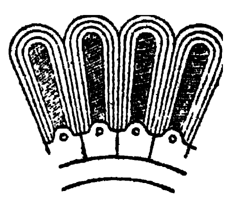


FIG. 5.

Armed (*Her.*) Used to denote that the natural weapons of defence are of a tincture different from the rest of the animal.

Armes Parlantes (*Her.*) Coats of arms on which

the device is derived from the family name; also called CANTING HERALDRY.

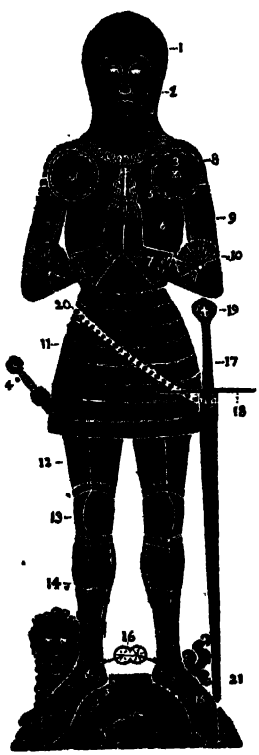
Armet (*Arm.*) A helmet worn on the Continent in the fifteenth century. It was globular in form.

Armilausa (*Cost.*) "A body garment, the prototype of the surcoat."—MEYRICK.

Arming Press (*Bind.*) A light kind of blocking press (*q.v.*) used by hand. So called originally because such presses were generally employed for impressing *armorial bearings* on the sides of books.

Armorial Bearings. Heraldic devices used to distinguish families, corporate bodies, and counties; in the case of family and feudal arms descending from father to son. ARMS OF DOMINION: The national arms borne by the sovereign. Armorial bearings were first employed by the Crusaders, and took their rise from knights painting upon their banners a distinctive figure to enable them to be distinguished when clad in armour. They became hereditary in families at the close of the twelfth century. *See also* HERALDRY.

Armour (*known also as* **Harness** *and* **Mail**). A covering worn to protect the body in battle. Metal armour of various kinds was used extensively by ancient nations, notably by the Egyptians, Greeks, and Romans; but it served to protect a portion of the body only, and consisted of helmet, shield, cuirass, and greaves. It is known that the *Hastati* of the Romans wore flexible cuirasses, but there is no definite evidence as to how they were constructed. It was in the tenth century that complete metal armour began to be worn in Europe, and it continued to be worn, subject, of course, to many variations of both style and construction, until the eighteenth century, when the more general use of firearms and field artillery rendered it useless. MAIL, the type of armour worn in the tenth century, consisted of rings of iron firmly sewn flat on cloth or leather. Later the rings were linked, and formed a garment themselves. This form of armour was known as CHAIN MAIL. Small flat pieces of metal were also used, and this armour is known as SCALE ARMOUR. Subsequently single plates were substituted to cover various parts of the body, until eventually, in the fourteenth century, the period during which the greatest development in body armour occurred, the whole body became encased in this kind of armour, known as PLATE ARMOUR. This, the last form of complete body armour, was often richly engraved and embossed. The illustration shows a complete suit of plate armour of the early fifteenth century, the names of the various parts being indicated.—C. F. T.



1. Bascinet.
2. Gorget.
3. Roundel.
4. Miséricorde.
5. Gadlings.
6. Cuirass.
7. Gauntlet.
8. Epaulière.
9. Brassart.
10. Coudière.
11. Skirt of Taces.
12. Cuissart.
13. Genouillière.
14. Jambart.
15. Solleret.
16. Rowelled Spur.
17. Sword.
18. Crossguard
19. Pommel.
20. Sword-belt.
21. Chape.

ARMOUR: SIR JOHN LYSLE, THRUXTON, HAMPSHIRE.
From "Brass," engraved c. 1425.

Armourer's Art. Originally, simply to make the armour, but afterwards to apply enrichment.

Arms (*Her.*) *See* ARMORIAL BEARINGS (*Her.*)

Arnott's Valve. The purpose of this valve is to act as an outlet for the vitiated air of rooms. It is a metal box arrangement, generally placed near the ceiling and opening into the chimney. The pressure of air from the room forces the valve inwards—*i.e.* towards the chimney—allowing impurities to escape; but when the pressure is greater from the chimney the valve closes.

Aromatic Compounds. A term originally applied to a number of substances having an aromatic odour. Most of these were found to be benzene derivatives; hence the term is now used to designate the benzene derivatives as a whole.

Arpeggio (*Music*). The sounding of the notes of a chord in succession instead of simultaneously.

Arquebus, *or* **Arcubus,** *also* **Harquebus.** Earliest form of trigger gun.

Arraché (*Her.*) *See* ERASED.

Arrack. The spirit distilled from the fermented liquor (toddy) of the sap from various palm trees.

Arras. A rich cloth originally woven at Arras in France; also the name of a screen of the same material which was hung round rooms.

Arris (*Building*). The sharp exterior angle formed by the intersection of two plane surfaces.

Arris Gutter (*Building*). A V-shaped gutter.

Arrow. A weapon of great antiquity, which varied much in length and shape; generally it was slender, straight, and pointed. Thick ones used with cross-bows were called bolts or quarrels. The arrows of the early Britons were tipped with flint or bone. After the Norman Conquest the English became most expert bowmen with the deadly "cloth-yard" shaft.

Arrowroot. Is obtained from the rhizomes of a plant, *Maranta arundinacea* (*Marantaceæ*), which is a native of India and the West India Islands. It is said to owe its name to the Indians using it to absorb the poison from wounds inflicted by poisoned arrows. Arrowroot is a pure starch, and is of value as an article of diet for invalids. The common adulterants are tapioca, potato starch, and sago.

Arsenic, As. Atomic weight, 75. A dark grey metallic-looking element. It is brittle and crystalline, and sublimes about 450° without melting; but it melts if heated under pressure. Its vapour has a tetratomic molecule at 860°, a diatomic molecule at 1736°. Heated in air, it is oxidised to arsenious oxide; the same oxide is formed when it is heated with strong sulphuric acid. Nitric acid oxidises it to arsenic acid. Hydrochloric acid is without action. The element is obtained by heating arsenical pyrites (FeS_2FeAs_2) out of contact with air. Alloyed with lead in shot making. In nature, arsenic

occurs in masses of tin white to dark grey colour, with a sub-metallic lustre; the masses are granular and often mammillated. Usually some antimony is present as an impurity, and it is often associated with lead and silver ores. Arsenic also occurs in combination as ARSENOLITE, ORPIMENT, REALGAR, and many arsenides and arseniates. Native arsenic is found in Cornwall, Saxony, Bohemia, Norway, United States, etc.

Arseniate of Lead (*Min.*) A synonym for MIMETITE (*q.v.*)

Arsenical Nickel (*Min.*) A synonym for KUPFERNICKEL (*q.v.*)

Arsenical Poisoning. Arsenic is used in the colouring of artificial flowers, toys, etc. It has also been found to a large extent in some wallpapers, the poison being given off either in the form of dust particles or as a gas.

Arsenical Pyrites (*Min.*) A synonym for MISPICKEL (*q.v.*)

Arsenic Compounds. ARSENIURETTED HYDROGEN, AsH_3: Formed pure when an alloy of zinc and arsenic is acted on by hydrochloric acid; mixed with hydrogen when any soluble arsenic compound is acted on by pure zinc and dilute sulphuric acid. It is a gas; extremely poisonous; resolved into its elements when heated (*see* MARSH'S TEST). Passed into silver nitrate solution, it gives a black precipitate of silver and a solution of arsenious acid. Traces of it are supposed to be formed from wallpapers coloured by green arseniacal pigments. ARSENIC CHLORIDE, $AsCl_3$: A colourless fuming liquid decomposed by water into arsenious and hydrochloric acids. Formed by direct union of its elements. ARSENIOUS OXIDES, As_4O_6; also called WHITE ARSENIC: A heavy white solid having three allotropic modifications; sparingly soluble in water; more soluble in hydrochloric acid; very soluble in alkalis forming alkaline arsenites. Very poisonous. Obtained on large scale in roasting tin ores containing arsenical pyrites. ARSENIC OXIDE, As_2O_5: White deliquescent solid obtained when arsenic acid is carefully heated. ARSENIC ACID, H_3AsO_4: A white solid, obtained when arsenic or arsenious oxide is oxidised with nitric acid. ARSENATES: Salts of arsenic acid. The most important is. SODIUM ARSENATE, $Na_2HAsO_4 12H_2O$, obtained when arsenic acid is made alkaline with sodium carbonate and the solution crystallised. It is isomorphous with sodium phosphate, and used in dyeing. ARSENITE: Salts of arsenious acid, H_3AsO_3. COPPER HYDROGEN ARSENITE, $CuHAsO_3$, is Schule's green—an important green pigment formed by adding copper sulphate solution to a solution of arsenious oxide in caustic soda. ARSENIOUS SULPHIDE, As_2S_3: Formed as a yellow precipitate when sulphuretted hydrogen is passed into an acid solution of an arsenic compound (important test for arsenic). Insoluble in hot strong hydrochloric acid; soluble in alkalis and alkaline sulphides. Heated in air, gives arsenious oxide.

Arsenolite (*Min.*) Also called white arsenic. It is native arsenious acid, As_2O_3, and occurs as a sublimate of minute octahedral crystals of glittering lustre on decomposing arsenical ores, and also in pulverulent crusts. It is extremely poisonous. From the Harz and Saxony and many localities where arsenical ores occur. Its crystallographic system is cubic.

Arsine. *See* ARSENIURETTED HYDROGEN, *under* ARSENIC COMPOUNDS. It is another name for this.

Artemis. The Greek name of Diana, goddess of the moon and of hunters. Represented as a huntress. The incident of Actæon, turned into a stag, being torn to pieces by his own hounds for gazing on the goddess while bathing, is a well known subject in art.

Artery (*Zoology*). The term applied to a blood vessel that contains blood passing from the heart to the various organs. The arterial walls are thick and very elastic.

Artesian Wells. These derive their name from the fact that the first well of the kind was sunk in the province of Artois in France. They are formed by making a perpendicular boring, usually of great depth, in a basin of the strata. When the boring reaches below an impervious stratum, a constant and spontaneous supply of water is afforded. The water from this source is pure and palatable. Sodium chloride, sodium carbonate, and free ammonia are often found in waters obtained from these wells.

Artificial Illumination. The chief illuminants are: coal gas, electric light, acetylene, and oil. Lighting is responsible for the addition of many impurities to the air of rooms, carbon dioxide in particular. It is computed that each cubic foot of gas burnt per hour pollutes as much air as would be rendered impure by a person while at rest. The following is a list of illuminants in their "hygienic" order: Electric light; coal gas—incandescent; coal gas—Argand burner; coal gas—batswing burner; paraffin lamp; and candles.

Artificial Stone. Artificial stones may be divided into three classes: (1) Stone resembling concrete, consisting of admixtures of cement and crushed fragments of some hard natural stone. (2) A soft natural stone which has been hardened and made stronger by artificial treatment. (3) Homogeneous "stone" prepared from various mixtures of clay, such as terra-cotta or common brick. (1) The chief forms of the first class are as follows: (*a*) GRANOLITH (Stuart's): This consists chiefly of crushed granite mixed with Portland cement. It is chiefly used for paving, in which form it is very durable. It also possesses the valuable property of withstanding intermittent action of water, and it has been used in the graving dock at Glasgow with success. (*b*) NON-SLIP STONE: This consists of chips of hard Yorkshire stone mixed with cement. It is cast in blocks and hardened under hydraulic pressure, forming a very durable paving material, with a surface which does not become too smooth, and therefore slippery, as it wears away. (*c*) VICTORIA STONE: This contains crushed granite, which has been washed free from alkali. This is mixed with cement and water, and moulded into suitable blocks. When it has been hardened by exposure to the air, it is soaked in a solution of sodium silicate and further exposed to the air, when it becomes extremely hard and durable. It is very suitable for paving, sills of doors, etc. (2) In the second class a good example is what is termed MOREAU MARBLE. The preparation of this is, in brief, a method of producing a fairly hard ornamental marble from a cheap and inferior limestone. A soft limestone is selected, and the surfaces dressed and smoothed. Veins are produced by tinting the stone artificially. It is then soaked in a solution of zinc sulphate and allowed to dry, first at 50° C. and then at 100° C. It has now become very hard, and is capable of taking a very high polish. With the exception that it cannot be obtained pure white, it has nearly all the valuable properties of natural marble. (3) In the third class

the method of formation is analogous to the manufacture of bricks, which are, in a sense, a form of artificial stone. For the method employed, *see* the article on BRICKS.—G. F. G.

Artisan. A skilled workman or mechanic. The name was formerly applied to artists.

Artist. One skilled in some branch of the fine arts: a good workman in any trade.

Artist's Proof. *See* PROOF.

Art Paper for Lithographic Printing. Ordinary paper (usually made from esparto and wood) coated with a mixture of china clay or barytes and glue.

Asafœtida. *Ferula narthex* and *F. Assafœtida* (order, *Umbelliferæ*). A gum resinous drug obtained by cutting and scraping the roots. Owing to its powerful odour, it is sometimes used in solution for detecting faults in drains.

Asbestos *or* **Asbestus** (*Min.*) A fibrous variety of amphibole; the fibres are usually so fine as to be flexible and separated by the fingers easily. Amianthus is an even more silky form. A typical analysis is: silica = 59·2, magnesia = 31·0, ferrous oxide = 8·3, alumina = 0·19, hydrofluoric acid = 1·31 per cent. It is found in Corsica, Savoy, Tyrol, Hungary, etc., and largely in the United States. Asbestos is very incombustible, and serves as the basis of various forms of fireproof card, cloth, and paper, which are of great value in the arts. Pipes conveying steam, hot gases, etc., are often coated with a preparation of asbestos.

Asbolane (*Min.*) This mineral, though used as an ore of cobalt, is really an impure hydrous oxide of manganese, WAD (*q.v.*), containing a variable proportion of oxide of cobalt. It is also called EARTHY COBALT. It occurs in earthy black masses with somewhat unctuous touch. Found in Cornwall, Saxony, United States, etc.

Ascending Letters (*Typog.*) All letters with upstrokes, as b, d, h, k, l, etc.

Ash. The residue which remains when organic matter of vegetable or animal origin is heated with exposure to air; *e.g.* bone ash is the residue—chiefly calcium phosphate—left when bones are heated in the air.

—— (*Dec.*) This wood is imitated by grainers by painting a ground obtained by mixing burnt umber and raw sienna with a little black. The graining is done with yellow ochre and burnt umber, or a mixture of raw sienna, burnt sienna, and raw umber. *See* WOODS.

Ashlar (*Building*). Masonry built of rectangular blocks over 12 in. deep on face.

Ashlaring (*Carp.*) Where a room is formed in a roof, the rafters cut the floor level at an acute angle. Short studs (ashlars) are fixed to the rafters and joists, and then lathed and plastered.

Ash Pan (*Eng.*) The tray placed beneath the bars of a grate or fire box to catch the ash.

Ash Rims (*Cycles*). *See* WOODEN RIMS.

Asp (*Archæol.*) A species of viper found in Egypt; in colour greenish, mingled with brown. Often figured on Egyptian monuments. Symbolical of malice.

Asparagine, $\begin{array}{l} CH_2CONH_2 \\ | \\ CHNH_2COOH \end{array}$. A white crystalline solid found in many plants; sparingly soluble in water and alcohol; it contains an asymmetric carbon atom (*q.v.*) The lævo form occurs in asparagus, peas, beans, lettuce, etc., and has a disagreeable taste. The dextro form, which occurs along with the lævo form, in the sprouts of vetches, has a sweet taste. Can be made artificially by heating maleic anhydride (*see* MALEIC ACID) with alcoholic ammonia.

Aspartic Acid, $\begin{array}{l} CHNH_2COOH \\ | \\ CH_2COOH \end{array}$. (*Aminosuccinic Acid*). A decomposition product of albumin, obtained by boiling asparagine with an acid. Crystalline solid. Has an asymmetric carbon atom (*q.v.*) The natural acid is lævorotatory. It yields malic acid when acted on by nitrous acid.

Aspectant (*Her.*) The same as AFFRONTÉ.

Aspen. *See* WOODS.

Asperges (*Archæol.*) Holy water sprinkler, used in the service of the Roman Catholic Church.

Asphalt. A native mixture of hydrocarbons which occurs under a great variety of conditions. It is very often associated with deposits of gypsum and of rock-salt, or with strata which have been formed in the concentrated solution found in inland lakes. It occurs also in rocks of very diverse ages. The asphalt of the Val de Travers, Neuchâtel, occurs in a bituminous limestone of Neocomian age. The Dead Sea and the Pitch Lake of Trinidad are other well known localities. The composition of asphalt varies almost as much as its mode of occurrence. Asphalt is valuable, in building, for making waterproof courses and for paving purposes, both as a cement for wood blocks and as the basis of various excellent paving compositions.

Asphaltum (*Paint.*) A brown paint made from asphalt.

Asphyxiator (*Plumbing*). An apparatus for testing drains by charging them with smoke.

Aspiration, Ventilation by (*Hygiene*). Is the extraction or withdrawal of the impure air (generally by the aid of machinery), fresh air rushing in to take its place. The ordinary chimney illustrates the method very well. Steam jets discharging into chimneys, fans, and screws are used in this system of ventilation. It is more effective and less costly than the propulsion method, though the air is not so easily controlled as in the latter.

Assai (*Music*). Very, sufficiently.

Assimilation (*Botany*). A process carried out in the green portions of a plant, and consisting of the absorption and decomposition of the carbonic dioxide in the air. The agent in the process is the chloroplastid (*q.v.*), and the source of energy the sunlight.

Astatic Needles (*Elect.*) A pair of magnetic needles of equal magnetic moment fixed together with their poles in opposite directions, and mounted so as to turn freely. This arrangement is exceedingly sensitive to a small magnetic force, owing to the controlling force due to the earth's magnetism being reduced to a minimum. Such a combination of two magnetic needles is used in the astatic galvanometer. *See* GALVANOMETERS.

Asteroid (*Astron.*) The minor planets lying between Mars and Jupiter. Over three hundred of these bodies are known.

Astragal (*Architect.*) A small moulding of semicircular cross section. *See* TORUS *and* BEAD.

Astragal (*Carp.*) A semicircular bead above the surface of the framing.

—— (*Plumbing*). A bead moulding round a lead pipe.

Astragalus (*Archæol.*). The knuckle bone. It has been used in a child's game from the time of the Greeks till now.

Astrakhan (*Zoology*). The fleece of black lambs of a variety of sheep (*Ovis aries steatophyga*), found in the province of Astrakhan, and in Bokhara, Persia, and the Asiatic steppes generally. The wool of the lambs of this species is curled, and resembles fur; but the coat of the adult sheep consists of short close hair, and yields no wool capable of being manufactured.

—— (*Woollen Manufac.*) A type of pile fabric covered with curls and made in imitation of the natural skin.

Astronomical Clock. A clock keeping sidereal time (*q.v.*) It indicates 0h. 0m. 0s. when the first point of Aries crosses the meridian.

Astronomical Telescope (*Light*). A telescope consisting essentially of a long focus lens forming a real image at or near its focus, and an eyepiece by which this image is magnified. The image seen by the eye is inverted, but this is no disadvantage when viewing a heavenly body.

Astronomy. The science that deals with the position, nature, and motion of the heavenly bodies.

Astylar (*Architect.*) A method of treating an elevation of a building without the use of columns.

Asymmetric Carbon Atom. Carbon is a tetravalent element (*q.v.*) When two or more of the atoms, or groups of atoms, attached to a carbon atom are the same, only one compound is known—*e.g.* only one compound of the formula $CHCl_3$ is known. But when all the four atoms, or groups of atoms, attached to a carbon atom are different, two compounds are known. These two compounds differ only in one important respect: the one rotates the plane of polarisation of PLANE POLARISED LIGHT (*q.v.*) to the right, the other to the left. In chemical behaviour the two compounds are identical. In the formula for lactic acid,

$$\begin{array}{c} CH_3 \\ | \\ H - C - OH \\ | \\ COOH, \end{array}$$

the central carbon atom has four different groups attached to it; hence lactic acid exists in two forms, one of which is dextrorotatory and the other lævo-rotatory. If equal quantities of the two forms are mixed, we get a product which has no action on polarised light—it is said to be optically inactive (also called the racemic modification). The theory of Le Bel and Van t' Hoff accounts for the phenomenon as follows: the asymmetric carbon atom is assumed to be at the centre of a regular tetrahedron, and the four groups are attached one at each angular point. This will account for the two compounds. Let A, B, C be the base of the tetrahedron (in the plane of the paper) and D the apex (above the plane of the paper); fig. 1. Also let A, B, C, D represent the four different groups. This will be one modification. Now interchange any two of the groups, say B and D, we get fig. 2. Turn the tetrahedron about the *edge* A, C, so that the apex B again comes into the plane of the paper, fig. 3. In case (1) A, B, C run clockwise; in case (3) counterclockwise: thus we have two different compounds. If in case (3) any two letters are interchanged, we shall again get case (1), so that *only* two compounds are possible.

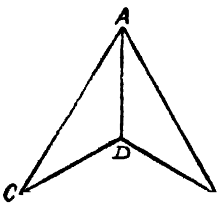


FIG. 1.

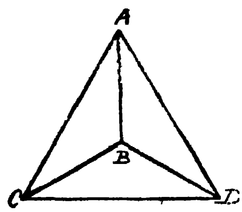


FIG. 2.

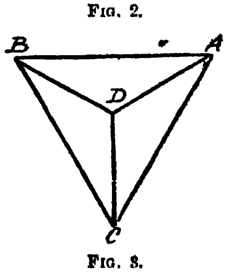


FIG. 3.

Asynchronous Motor (*Elect. Eng.*) Motors actuated by an alternating current may be classified as SYNCHRONOUS (*q.v.*) or ASYNCHRONOUS, according as the rate of rotation of the moving portion does, or does not, correspond to the frequency of the current. *See* MONOPHASE *and* POLYPHASE MOTORS.

Atacamite (*Min.*) A hydrous oxychloride of copper, $CuCl \cdot 3Cu(OH)_2$: oxide of copper = 53·6, chloride of copper = 30·2, water = 16·2 per cent. Colour, rich deep green; in small rhombic crystals; also massive. From Cornwall, the desert of Atacama in South America, Spain, Australia, etc.

At Bay (*Her.*) Said of a stag with a head bowed ready for attack or defence.

Atelier (*Art*). Literally a workroom or workshop: the studio of a painter or sculptor.

A Tempo (*Music*). In time: used after some term altering the speed.

At Gaze (*Her.*) Full faced or facing the observer.

Athene, Athena. In Greek mythology, the goddess of wisdom, arts, and sciences; represented with spear and helmet and the ægis of her father Zeus. Three celebrated statues of Athene were executed by Pheidias; the first, which was of ivory and gold, was erected on the Acropolis of Athens. Called by the Romans Minerva.

Athletes (*Art*). Those skilled in physical exercises. They have provided the best models for artists from the flourishing period of Greek sculpture to the present day.

Atlantes, *pl. of* **Atlas** (*Architect.*) The name given by the Greeks to the carved figure or half figure of a male used as a column. Persians and Telamones are other names for Atlantes. *See* CARYATID.

Atlas (*Paper*). Writing paper of a size 36 × 26 in.

—— (*Zoology*). The first of the neck (cervical) vertebræ. It has two large articular surfaces for the attachment of the skull.

Atmolysis (*Phys.*, *Chem.*) The separation of two gases by their different rates of effusion through a porous partition. The rates of effusion of two gases are inversely as the square root of their densities; thus hydrogen effuses four times as fast as oxygen, which is sixteen times as dense under equal conditions of pressure and temperature.

Atmosphere. Consists of nitrogen (76·95); oxygen (20·91); argon, and the allied elements helium, krypton, neon, xenon (1·00); carbon dioxide (0·04);

a variable amount of water vapour, ammonia as carbonate, nitrite, and nitrate; solid matter. The numbers give the percentage by volume. The nitrogen serves principally as a diluent, but certain leguminous and other plants obtain part of their nitrogen from atmospheric nitrogen through the agency of bacteria. The oxygen is essential for the respiration of all animals and plants, and for all processes of combustion. The carbon dioxide is produced in all processes of respiration, combustion, fermentation, and putrefaction; that it does not increase in amount appreciably is due to the fact that the green parts of plants decompose it under the influence of sunlight, using the carbon to build up their substance and liberating oxygen. Evaporation from seas, rivers, lakes, and the respiration of animals, as well as processes of combustion, furnish the water vapour. Ammonia owes its origin to the decay of nitrogenous organic matter, while the nitrous and nitric acids with which it is combined are formed by electrical discharges occurring in the atmosphere. Minute quantities of hydrogen peroxide and ozone are also present in the air of places far removed from towns; the true origin and amounts of these two substances are not known with certainty. The amount of nitrogen and oxygen is estimated (*a*) gravimetrically by freeing the air from other substances except argon and its allies, and passing it over red-hot copper and collecting the nitrogen; the increase in weight of the copper gives the oxygen, and that of the vacuous vessel in which the nitrogen is collected gives the nitrogen. (*b*) Volumetrically by means of the eudiometer (*q.v.*) The carbon dioxide is estimated by shaking a known volume of baryta water of known strength with 10 litres of air; part of the baryta unites with the carbon dioxide, and the rest is ascertained by titration with standard oxalic acid (Pettenkofer's method). Aqueous vapour is estimated by means of the hygrometer (*q v*), and also by aspirating a large volume of air (20 litres) through a weighed tube containing pumicestone soaked in sulphuric acid, which absorbs the water (absolute method). Ammonia and its compounds are determined in rain water only, as this washes them out of the atmosphere. The solid matter floats as dust in the air, which it can do in virtue of its fine state of division. It consists of silica, iron and its oxides, common salt (NaCl) from the spray of the sea, vegetable organisms, moulds, spores, and bacteria. Mr. Webb (L. & N.W.R. Co.) states that 18 tons of steel per day are removed from the rails of his company by wear and oxidation; doubtless much of this floats in the air as dust for long periods. The presence of moulds and bacteria is proved by the occurrence of fermentation and putrefaction. Milk turns sour because of numerous bacteria and moulds entering it from the air and producing lactic acid from the milk sugar. Putrefaction of meat is brought about in a similar manner. These changes do not occur in milk and meat kept in sealed vessels, when the vessels and their contents have been sterilised previous to sealing. The number of micro-organisms in the air is less in the country than in towns, and less at an altitude than near the ground. Thus Frankland has shown that at Reigate there were on an average 14 organisms in 10 litres of air: at St. Paul's Cathedral, 56 organisms at the base, 29 in the Stone Gallery, and 11 in the Golden Gallery, in 10 litres of air. The number of organisms is less in winter than in spring and summer. There are certain substances always present in the air of towns which are not present in pure country air; chief amongst these are sulphuric acid and products of the incomplete combustion of coal. The sulphuric acid owes its origin to the sulphur compounds present in coal and coal gas, and has a most injurious effect upon many kinds of stone, but not, apparently, upon healthy people. Incomplete combustion of coal produces soot, which consists of carbon and adhering tarry matters. To judge of the effect produced upon the atmosphere by the combustion of coal it is calculated that about 1 per cent. of the coal is given off as soot, a fair amount of which passes into the air; and 1 lb. of coal requires 240 cubic ft. of air for complete combustion. Fogs are produced in the atmosphere by the partial condensation of water vapour upon dust particles as nuclei: in the country the fogs are white, being of the same nature as cloud; but in towns the nuclei are largely the soot particles, and the yellow colour of the fog is due to soot and its accompanying tarry matter. In towns, too, during fog, the amount of carbon dioxide is much higher than in the country; it may be twice as much. In an inhabited room it may rise to ten times the normal amount. During respiration, besides carbon dioxide, putrefiable organic matter is given off, so that the bad effect of the air of a crowded room is due in part to this as well as to defect of oxygen. When the carbon dioxide from respiration reaches ·2 volumes per 1,000 above the normal value of ·4 volumes, the air of the room begins to have a close or stuffy smell; below this value the air can be breathed without any ill effects, but it should not be allowed to be further polluted.—W. H. H.

Atmosphere, Pressure of (*Phys.*) The hydrostatic pressure due to the weight of the air. It is approximately 15 lb. per square inch at the surface of the earth, and can support a column of mercury about 30 in. high. For many purposes of reference, an arbitrary standard of atmospheric pressure equal to that of 76 cm. of mercury is adopted. For some purposes a pressure of one million dynes per square centimetre is assumed, which is somewhat less than the "normal pressure," being more nearly equal to 75 cm. of mercury

Atmospheric Engine (*Eng.*) The earliest form of beam engine, in which the steam was suddenly condensed in the cylinder and the piston forced down by atmospheric pressure alone.

Atmospheric Line (*Eng.*) The line on an indicator diagram (*q.v.*) which is traced out by the pencil when at rest—*i.e.* when nothing but the pressure of the air acts on each side of the piston of the indicator.

Atolls. Annular groups of coral reefs and islets enclosing a central lagoon, and standing at a variable but small elevation above the level of the sea. Their slope beneath the sea on the inner side is usually at a low angle, while the outer slope usually plunges rapidly down into deep water. They appear to form a coronet upon the head of an elevated portion of the sea bottom. Their origin has given rise to much controversy.

Atom (*Chem.*) An atom (in the chemical sense) is the smallest particle of an element that can exist; that is, the atom is the limit of divisibility of the matter composing the element. This definition does not exclude the possibility of further division into smaller particles; it simply lays down the theory that the smaller particles cannot be regarded as having the properties of the element to which the

atom belongs. Experiment has now proved that these smaller particles do actually exist; they are given off during the passage of electricity through a gas at low pressures, and serve as carriers of negative electricity. The name ELECTRON or CORPUSCLE has been applied to them by various writers. An electron has been shown to have a mass not more than one-thousandth that of an atom of hydrogen Probably an atom of an element is a collection of these corpuscles, and the difference between the atoms of two different elements is due to a difference in the method of arrangement or of the mode of motion of the electrons constituting the atom. *See also* ELECTRON *and* RADIATION.

Atomic Heat (*Chem.*) This is the name given to the value of the product Atomic Weight × Specific Heat. It is equal to 6·4, and is constant (approximately) for all elements in the solid state. Boron, carbon, silicon, elements of low atomic weight and high melting point, give lower values than 6·4; but as the specific heat is determined at higher and higher temperatures, they become more nearly normal.

Atomic Theory (*Chem.*) This theory is the very foundation of modern chemistry; it had its origin in Dalton's Atomic Theory published in 1800. It assumes matter to be divisible up to a certain point only, the ultimate particles being called atoms. Atoms of the same element are all alike; but an atom of one element differs from an atom of another element in weight and in chemical properties. Where chemical combination occurs between two elements, it does so by means of their component atoms. This last statement accounts for the Law of Multiple Proportions (*q.v.*)

Atomic Volume (*Chem.*) The quotient

$$\frac{\text{Atomic Weight}}{\text{Specific Gravity}}$$

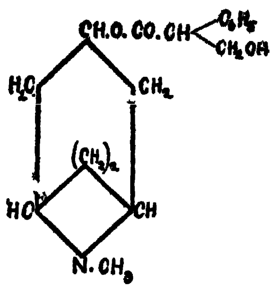
is called the atomic volume of an element. It is supposed to represent the relative volumes occupied by the atoms of elements.

Atomic Weight (*Chem.*) The smallest weight of an element which enters into a molecule of any of its compounds. The principle underlying the determination of atomic weight is as follows: Find the molecular weight (*q.v.*) of as many compounds of the element as possible. Analyse these compounds so as to determine the percentage of the element in each. Calculate from these two results the weight of the element contained in the molecular weight of each compound. The smallest value obtained is the Atomic Weight. In the case of elements in the solid state the Atomic Weight is related to the Specific Heat; thus: Atomic Weight × Specific Heat = 6·4 (Dulong & Petit's Law). The absolute weight of an atom of any element is unknown; so that the atomic weights have to be referred to some arbitrarily selected standard. Sometimes the atomic weight of hydrogen is put = 1, and all others expressed in terms of it; it is now very common to take the atomic weight of oxygen as = 16, and express all other atomic weights in terms of that, in which case H = 1·01.

Atomiser *or* **Atomising Carburetter** (*Motor Cars*). A SPRAY CARBURETTER (*q.v.*)

Atrium (*Architect.*) That court of a Roman dwelling house which was nearest to the entrance, and which served as a waiting room. The central portion of it was usually open to the sky. The same name is also given to the forecourt of an Early Christian Church. *See* PERISTYLIUM.

Atropine. An alkaloid obtained from the leaves and root of belladonna (deadly nightshade). Shining needles; can be sublimed; optically inactive. Soluble in alcohol and chloroform. Powerful poison; dilates the pupil of the eye. On treatment with nitric or acetic acids, it forms apoatropine, $C_{17}H_{21}NO_2$. On hydrolysis, yields tropin and tropic acid,



$$C_{17}H_{23}NO_3 + H_2O = \underset{\text{Tropin.}}{C_8H_{15}NO} + \underset{\text{Tropic acid.}}{C_9H_{10}O_3}.$$

Atropine can be reproduced by the union of these two substances. Atropine is isomeric with hyoscyamine, and the latter, on hydrolysis, also yields tropin and tropic acid.

Attacca (*Music*). Go on to the next movement without break.

Attachments (*Art*). The manner in which a limb is shown fastened to the body.

Attic (*Architect.*). The topmost story of a building above the main cornice.

Attic Base (*Architect.*) A base moulding used in Greek. Roman, and Renaissance architecture, consisting of two tori separated by fillets and a scotia.

Attic Order (*Architect.*) The pilasters used to decorate the front of an upper story above the main cornice.

Attired (*Her.*) The antlers of a stag.

Attracted Disc Electrometer (*Elect.*) *See* ELECTROMETERS

Attraction and Repulsion (*Physics, etc.*) A force between two bodies tending to draw them together or force them apart. These forces are now referred in most cases (*e.g.* in electric and magnetic phenomena) to certain actions of the nature of stresses and strains, produced in the medium between the two bodies. *See* LINES OF FORCE.

Audition, Limits of (*Sound*). Somewhat uncertain and variable with different observers. The lowest note audible is probably one of 30 vibrations per second; the highest may have from 10,000 to 20,000 vibrations per second. This gives a probable range of 9 octaves.

Auger. A tool similar to a gimlet, only much larger.

Augite (*Min.*) One of the pyroxene group of minerals, often in the form of short prisms. Black or very dark green. A silicate of calcium, magnesium, aluminium, iron, and manganese Silica = 17·63, lime = 20·87, magnesia = 12·9, alumina = 6·74, ferrous oxide = 11·39, manganous oxide = 0·21, water = 0·28 per cent. Monosymmetric. Found in many basic volcanic rocks, widely distributed.

Augite Diorite. A holocrystalline compound of ferro-magnesian minerals (including one of the pyroxenes) and a plagioclase felspar, in which the structure of the whole mass is granitic. It is always a rock of plutonic origin, and has generally been formed at a considerable depth below the surface.

The dyke rocks correlative to it are now termed PORPHYRITES, while the correlative lavas are ANDESITES. Augite diorite graduates into GABBRO DIORITE and then into GABBRO (*q.v.*)

Augite Syenite. A holocrystalline compound showing granitic structure, composed essentially of othoclase felspar (without any conspicuous development of quartz), together with ferro-magnesian silicates, amongst which one of the pyroxenes forms part. The rock is of sub-acid composition, and is of plutonic (and usually deep-seated) origin. Its correlative dyke rocks are various, and include the MICA TRAPS. The correlative lavas are TRACHYTES.

Augmentation (*Her.*) An addition to a shield to commemorate an important event in the life of its possessor.

Augmented Interval (*Music*). An interval containing one semitone more than perfect, or major.

Augur (*Archæol.*) Among the Romans a functionary whose office was to divine future events from the acts and flight of birds, natural phenomena, etc. There was a college of augurs, consisting in later times of four patricians and five plebeians. One of the symbols of office was the lituus or crooked staff.

Auramine, $\begin{matrix}(CH_3)_2N - C_6H_4\\(CH_3)_2N - C_6H_4\end{matrix}\!\!>C = NH$. Usually met with as the hydrochloride – golden yellow leaflets. A basic yellow dye used in cotton dyeing and printing. *See also* DYES AND DYEING.

Aureola, Aureole (*Art*). The luminous cloud which forms the background to the figure of Christ or a saint. If intended to symbolise Christ, a cross is enclosed in the aureola. When only encircling the head, it is termed NIMBUS: the nimbus and aureole together form a GLORY.

Aureoled (*Her.*) Figures having the head surrounded by an aureole (*q.v.*)

Aureolin (*Paint.*) A bright yellow pigment used by artists. It is somewhat fugitive when exposed to light and air, is dissolved in acids, but unaffected by alkalies.

Auric, Aurous, Aurum (*Chem.*) Aurum is the Latin word for gold, and the symbol for gold, Au, is derived from it. The terms AURIC and AUROUS are applied to the two classes of gold salts—*e.g.* auric chloride is $AuCl_3$; aurous chloride, AuCl.

Auricles (*Zoology*). The two thin-walled chambers of the heart, into which the great veins open.

Auriferous Deposits. A comprehensive name for all kinds of rocks which yield gold in any form. It includes quartz reefs, and all of the many forms of strata yielding detrital gold.

Auriferous Pyrites (*Min.*) A variety of pyrites (*q.v.*) containing a workable quantity of gold. Nearly all samples of pyrites contain some gold, but it is more difficult of extraction than when it exists as "free" or metallic gold in the matrix.

Aurora. A luminous appearance seen in the sky towards the poles; it is due to some electrical phenomena, probably of the nature of an electrical discharge, and is accompanied by MAGNETIC STORMS (*q.v.*)

Authentic (*Music*). *See* MODES.

Author's Proof (*Typog.*) Proof bearing the author's corrections.

Autogenous Soldering. The process of joining two pieces of lead (or other metals) by placing them together and melting the lead at the junction by means of a hydrogen flame.

Automatic Ignition (*Motor Cars*). Firing the charge by the heat of the cylinder at the moment when the compression has reached its greatest value. An engine with this form of ignition requires special means of starting, and is, moreover, rather uncertain in action.

Automatic Loom (*Cotton*). *See* LOOM.

Automatic Valves (*Motor Cars*). Valves which are worked by a difference of pressure between the gases on the two sides, instead of by valve rods or levers. The admission valve in very many petrol engines acts in this manner; as the piston descends, a partial vacuum is produced in the cylinder, and the pressure of the mixture of air and petrol vapour opens the valve and rushes in.

Automobile. A general term for a mechanically propelled carriage which carries its own motive power.

Auto-Transformer (*Elect. Eng.*) A form of transformer (*q.v.*) with one coil only, whose ends are connected to the mains, forming the primary. The secondary is furnished by making connection to any two points in the coil, thus obtaining a lower voltage but larger current, as in the ordinary transformer.

Autumnal Equinox (*Astron.*) The time when the sun crosses the equator from north to south, passing through the First Point of Libra (*q.v.*) *See also* EQUINOXES.

Autunite (*Min.*) A hydrous phosphate of uranium and hydrate of calcium $(CaO.3U_2O_3)P_2O_5.8H_2O$: uranic oxide = 56–60 per cent., phosphoric acid = 13–15 per cent., lime = 5·5 per cent., water = 15–20 per cent. It crystallises in yellow rhombic plates. Cornwall, Siebengebirge, Russia, United States.

Auxiliary (*Clocks*). A secondary compensation piece fitted to the balance of a marine chronometer to reduce the "middle temperature error."

Auxiliary Note (*Music*). An unessential dissonant note, a second above or below one of the notes of a chord with which it is sounded.

Avagadro's Law states that equal volumes of all gases at the same temperature and pressure contain the same number of molecules. It is of fundamental importance in chemistry, as it follows from it that if we weigh equal volumes of two gases under the same conditions, the ratio of these weights is the ratio of the molecular weights. The molecule of hydrogen is believed to contain two atoms, so that its molecular weight is 2. Hence, if we find how many times heavier a given volume of a gas is than the same volume of hydrogen under the same conditions, and multiply the result by 2, we have the molecular weight of the gas.

Avantail, *also* **Ventaile** (*Arm.*) The movable part of a helmet which covered the face. It was superseded by the visor in the fourteenth century.

Avellane (*Her.*) A cross whose quarters resemble a filbert nut. When placed on the mondes of royal personages, it is an ensign of sovereignty.

Aventurine, Avanturine (*Glass*). A brilliant variety of glass of a brownish colour flecked with small gold-coloured spangles. This quality is produced by the addition of oxide of copper. Avanturine glass was first manufactured at Murano, near Venice, about the year 1600.

Aventurine Felspar (*Min.*) A variety of orthoclase (*q.v.*) containing minute spangles of tetanic iron or limonite.

Aventurine Quartz (*Min.*) A variety of quartz containing minute flakes of mica, which give it, when cut, a scintillating appearance.

Average. A mean or intermediate quantity. If there be n quantities, q_1, q_2, q_3, etc., and their sum be Q, then the average value of these quantities, often written $\bar{q}$, is given by the equation

$$\bar{q} = \frac{q_1 + q_2 + q_3 + \text{etc.}}{n} = \frac{Q}{n}$$

Average Current (*Elect. Eng.*) The average value of an alternating current in the simplest case (that of a curve of sines: *see* ALTERNATING CURRENT) is ·637 of the maximum current; but the effective or virtual value, the one required to be known for practical purposes, as it is equal to the equivalent continuous current, is ·707 of the maximum current. This value is obtained by calculating the mean value of the square of the current at each instant, and taking the square root of this value.

Aversant (*Her.*) A right hand which is turned so as to show the back. Sometimes termed DORSED.

Avicula (*Zoology*). A genus of marine bivalve shells forming one of the sources of the mother-of-pearl used in commerce.

Avoirdupois. The English system of weights. *See* WEIGHTS AND MEASURES.

Axe (*Building, etc.*) A large wood-cutting tool for rough work. Also a pointed hammer used by masons for dressing hard stone.

Axed Arch (*Building*). An arch with bricks roughly cut to shape, instead of being carefully "rubbed" to gauge. *See also* ARCH.

Axed Work (*Building*). Hard stone, such as granite, which has been dressed with an axe, leaving the surface somewhat ribbed or rough.

Axes (*Min.*). Crystallographic axes are imaginary lines of indefinite length intersecting in a common *origin*. Their relative length varies in the different SYSTEMS (*q.v.*) They are determined by the optical properties of the crystal in the first place, and, further, from a consideration of the crystal as a whole. In systems showing symmetry the intersections of planes of symmetry are often crystallographic axes. From the optical point of view, the axis is a direction in a crystal along which there is only one index of refraction, and every ray passing along or parallel to this direction obeys the ordinary law of refraction.

Axe Stone (*Min.*) A synonym of JADE (*q.v.*)

Axial Pitch (*Eng.*) The pitch of a screw or helix (*q.v.*) measured parallel to the axis.

Axial Relations (*Min.*). A term used in reference to the proportionate lengths of the crystallographic axes and the angles between them. *See* SYSTEMS.

Axis. The centre line of a body, or the line about which a figure or solid is symmetrical.

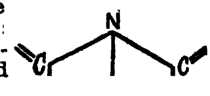
Axle (*Eng., etc.*) A rod or shaft with or on which a wheel or other rotating body turns.

Axle Box (*Eng., etc.*) The bearings or supports of an axle, combined with arrangements for lubricating the surfaces where friction occurs; practically a plummer block (*q.v.*), with a large oil or grease reservoir. Commonly used for railway carriages.

Azimuth (*Astron.*) The angle, measured horizontally, between a vertical circle through a star and the south point.

——, **Relative** (*Surveying*). The relative azimuth at a point A of the two points B and C is the angular distance, measured to the right, between one vertical plane passing through A and B, and a second passing through A and C.

Azines. Are compounds containing the group shown in the diagram. The simplest azine, phenazine, is a pale yellow crystalline solid with no dyeing properties; but many of the azines are important dyes—*e.g.* toluylene red (neutral red),



$$(CH_3)_2N.C_6H_3 \left\langle \begin{matrix} N \\ | \\ N \end{matrix} \right\rangle C_6H_2 \left\langle \begin{matrix} CH_3, \\ NH_2 \end{matrix} \right.$$

is an important cotton dye.

Azobenzene, $C_6H_5 - N = N -$ by reducing nitrobenzene with alkaline stannous chloride. Bright orange plates melting at 68°; insoluble in water, soluble in alcohol and ether.

Azo Compounds. Compounds containing the group $R_1 - N = N - R_2$, where R_1 may be an aromatic residue and R_2 either an aromatic or fatty residue; *e.g.* azobenzene is $C_6H_5 - N = N - C_6H_5$. Many azo compounds are important dyes—*e.g.* chrysoidine

$C_6H_5 - N = N - C_6H_3 \left\langle \begin{matrix} NH_2 \\ NH_2 \end{matrix} \right.$. *See also* CONGO RED, METHYL ORANGE, *and* DYES AND DYEING.

Azoimide, $\left.\begin{matrix} N \\ \| \\ N \end{matrix}\right\rangle NH$ (*Hydrazoic Acid*). A colourless liquid with penetrating smell, boiling at 37°; soluble in water and alcohol; explodes violently on heating. It is a strong acid; the salts with heavy metals are very explosive. May be obtained in aqueous solution by passing ammonia gas over sodium at 200°, forming sodamide; then passing nitrous oxide over the sodamide, dissolving in water, acidifying with sulphuric acid and distilling. Water is removed by fractional distillation, and then by calcium chloride. Also by action of nitrous acid on hydrazine (*q.v.*) and from amino-guanidine.

Azoxybenzene, $\begin{matrix} C_6H_5 - N - N - C_6H_5. \\ \diagdown\!\diagup \\ O \end{matrix}$

Long yellow needles melting at 36°. Obtained by reducing nitrobenzene with alcohol and sodium amalgam. Heated with iron filings, it gives azobenzene.

Azulejos. Wall tiles imitating mosaic work, made by the Spanish Moors in the fourteenth century, though some have been found made in the sixteenth century. Brilliant enamel colours were used. Excellent examples are to be seen in the Alhambra Palace, Granada. (2) A kind of glazed Dutch tile painted in colours.

Azulmic Acid, $C_4H_5N_5O$. A brown powder formed when a solution of cyanogen in water is allowed to stand.

Azure (*Her.*) Blue. It is generally contracted to *az*, and is indicated by horizontal lines in drawings.

AZURE.

—— (*Paint.*). Fine blue colour —*eg.* that of the sky. The name is sometimes given to cobalt and ultramarine.

Azurite (*Min.*) The blue carbonate of copper, $2CuCO_3 . Cu(OH)_2$, containing about 73 per cent. of oxide of copper; monosymmetric; deep blue in colour; it also occurs in the massive form (*q.v.*) It is a valuable ore of copper when in workable quantity. It is used to make the pigment mountain blue. Cornwall, etc., in Britain; Chessy in France; Siberia; Burra-Burra in South Australia, etc.

B (*Elect.*) Symbol for MAGNETIC INDUCTION (*q.v.*)

B (*Metallurgy*). The letter B is used to denote a quality of wrought iron; B.B. and B.B.B. indicate superior grades. *See* IRON, WROUGHT.

B (*Music*). The seventh note in the scale of C.

Babbitt's Metal (*Eng.*) A white alloy largely composed of tin, used for lining bearings to diminish the friction. A good composition is tin 96, antimony 8, copper 4 parts, by weight.

Babcock & Wilcox Boiler. *See* BOILERS.

Baccate Fruits (*Botany*). Succulent fruits usually termed berries, in which the seeds are embedded in a soft pulp. The date, orange, grape, currant, melon are examples.

Bacilli are micro-organisms, rodlike in shape. Many diseases are caused by organisms belonging to this group, as tuberculosis, typhoid, diphtheria, anthrax, influenza, etc. *See also* BACTERIA, ANTISEPTICS, *and* DISINFECTANTS.

Back (*Build.*) The extrados (*q.v.*) of an arch.

—— (*Carp.*) The top surface of a handrail, rafter, or any inclined timber.

Back Balance (*Eng.*) A disc-shaped weight used to counterbalance a loose eccentric which has to be moved on its shaft to reverse the engine; formerly commonly used on the engines of paddle steamers, but nearly obsolete owing to the use of LINK MOTION (*q.v.*)

Back Centre (*Eng.*) The "loose centre" or right-hand support of the work in a lathe.

Back Electromotive Force (*Elect. Eng.*) *See* COUNTER ELECTROMOTIVE FORCE.

Back Firing (*Eng., Motor Cars, etc.*) The explosion of the gas in the cylinder of a gas engine while the piston is performing the return stroke; or the explosion of unburnt gas after its release from the cylinder, before it escapes from the exhaust passages or from the silencer.

Back Gear (*Eng.*) An arrangement of gear wheels on the headstock of a lathe by which the velocity of the mandrel is made much less than that of the coned pulley through which the power is transmitted to the lathe. A pinion fixed to the pulley, which runs loose on the mandrel, drives a wheel on a parallel shaft, and a pinion keyed to the latter shaft drives a wheel keyed to the mandrel. When the reduced speed is not required the parallel shaft is thrown out of gear, and the loose pulley is fixed to the gear wheel on the mandrel. For very large lathes extra gearing for still further reducing the speed may be used.

Back Hearth (*Build.*) The portion of the hearth between the jambs, *i.e.* beneath the grate.

Backing (*Photo.*) Coating the back of a glass plate with a dull black substance, in order to prevent halation (*q.v.*)

Backing Boards (*Bind.*) Wedge-shaped boards made of hard wood, sometimes faced with iron. They are inserted between the book and the press in such a position as to help the binder when shaping the back of the book with the backing hammer, previous to binding. *See* BOOKBINDING.

Backing Off (*Cotton Spinning*). The reversing of the spindles on a mule so as to unwind the short length of spun thread coiled round during the operation of twisting and drawing out, previous to again winding on to build up the COP (*q.v.*)

Backlash (*Eng., etc.*) The amount of free movement between the two elements of a piece of gearing—*e.g.* in the case of a wheel and its pinion, the amount that one can be moved before the other commences to turn, or in a screw and nut the amount that one can be turned before the other begins to advance.

Back Lining (*Carp.*). The framing covering the wall under the window board.

Back Observation (*Surveying*). One made in a direction contrary to the order of a survey—*e.g.* one in which the eye is applied to the north sight of a miner's dial and not to the south. as in "FORE OBSERVATIONS."

Back Pages (*Typog.*) The pages of a printed sheet bearing even numbers are termed back or "verso" pages.

Back Painting. *See* CRYSTOLEUM.

Back Pedalling (*Cycles*). Checking the machine by pressing on the rising pedal; much practised by the riders of brakeless machines, but impossible on a free-wheel. In the latter case, however, a mechanical brake may be fitted, which is actuated by back-pedalling, the motion being given to the brake by a clutch on the axle which comes into action on pressing the pedals backward. *See also* CYCLES.

Back Plate (*Arm.*) The piece of armour which covered the back of the wearer.

—— (*Moulding*). A plate fastened to the back of moulding boxes to strengthen them when the molten metal is poured in.

Back Pressure (*Eng.*) The pressure in a cylinder due to the steam (or exhaust gas) which is still escaping by the exhaust port. Shown on the indicator diagram by the height of the bottom line of the diagram above the atmospheric line (*q.v.*) in non-condensing engines, or above the line of no pressure or absolute vacuum in condensing engines.

Back Putty (*Build.*) The putty put in the rabbets of a sash before the glass is inserted.

Back Rest (*Cotton Weaving*). The back crossrail or roller of loom over which the warp passes in a horizontal direction to the healds and reed.

Backs. A quarryman's term for one set of JOINTS (*q.v.*) traversing a rock, the other set being known as CUTTERS.

Back Saw. Any saw (*e.g.* a tenon saw) whose blade is stiffened by a bar fixed along one edge of the blade, the teeth being on the other edge.

Back Stay, or Back Rest (*Eng.*) A support for long work (*e.g.* shafting) which is being turned in the lathe; it prevents the work from springing away from the cutting tool. It travels with the slide rest, so as to be near the tool and close behind the point at which pressure is being applied.

Back Stops (*Cotton Spinning*). Buffers, used to prevent the mule carriage from going beyond a certain point during its inward run.

Backward Eccentric (*Eng.*) The eccentric used when the engine is reversed—*i.e.* one of the pair always used with link motion.

Backward Lead of Brushes (*Elect. Eng.*) *See* LEAD OF BRUSHES.

Backwasher (*Woollen Manufac.*) The machine through which the wool is passed after carding. It consists of the troughs containing the cleansing solution and of a number of hot drying cylinders over which the wool passes to a gill box.

Backwater Pump. A pump used in the manufacture of paper for conveying surplus water obtained from underneath the machine wire.

Bacteria. Minute unicellular plants devoid of chlorophyll (*q.v.*), and of a PARASITIC or SAPROPHYTIC habit (*see* PARASITES *and* SAPROPHYTES). They are found everywhere in nature. They attach themselves to the surface of every substance, and are present in varying numbers in air, water, etc. They are broadly divided into two classes—those that produce disease (the PATHOGENIC BACTERIA), and the harmless ones (the NON-PATHOGENIC BACTERIA). With conditions suitable to their growth and development they multiply with incredible rapidity. It is calculated that nearly seventeen million organisms are produced from one cell during twenty-four hours. Sunlight, heat, and certain chemical agents are destructive to many of these germs; their destruction is termed STERILISATION, and a substance capable of destroying them is termed an antiseptic, or in ordinary language "disinfectant," the latter word being also used in a somewhat wider sense.

Bacteriological Examination of Water. It is recognised that certain ZYMOTIC DISEASES (*q.v.*) can be produced by a contaminated water supply. These diseases are due to pathogenic bacteria (*see* BACTERIA). The presence of these disease-producing organisms can only be determined by bacteriological examination. It is extremely important, therefore, that water should be examined both chemically and bacteriologically.

Baculus (*Art. Archæol.*) Literally a stick; the long staff or rod used for support or as a symbol of power.

Bad Colour (*Typog.*) When too much or too little ink has been used.

Bad Copy (*Typog.*) A term applied to badly written MS.

Badge (=Cognisance in *Her.*) Originally a distinctive device borne by the followers of a knight; used later to identify the property of a person and as a sign of office. A badge cannot be regarded as armorial bearings.

Badger Plane (*Carp.*) A plane used for working wide rabbets.

Badgers (*Paint.*) Brushes made of badger's hair.

Badger Softener (*Dec.*) A broad flat brush the hairs of which are set to spread outwards, so that they may be lightly drawn over grained work during its progress to soften down the edges and smooth the marks representing the grain.

Badigeon (*Build.*) A mixture of plaster and stone used primarily for mending cracks in stonework. Afterwards used as a kind of paint or distemper to colour plaster work. A similar term is used for glue and sawdust worked up to repair woodwork.

Bad Matter (*Typog.*) A term applied to type intended for distribution.

Baffle Plate or Baffler (*Eng., etc.*) A plate fixed in the path of a moving fluid (liquid or gas) to check or alter the direction of flow. In furnaces it directs the hot gases (and therefore the flames) against parts required to be heated, instead of allowing them to pass directly along the flue.

Bag and Spoon Dredger (*Civil Eng.*) A dredging appliance resembling a large butterfly net, the ring round the net being strong enough to loosen material from the bottom of the river or channel.

Bag Hides (*Leather Manufac.*) Hides tanned for bag work. Light or half-tanned hides are split with a splitting machine, which divides the hide into two "splits." The upper or GRAIN SPLIT is used for bag work after being fully tanned and dyed. The lower or FLESH SPLIT is used for insoles and stiffeners in boots.

Bagshot Beds (*Geol.*) The Eocene strata which succeed the London Clay in the South of England. They are of marine origin and mostly consist of sands, which range to about 120 ft. in thickness. They are represented in Belgium by the Système Ypresian inférieur, and in the Paris Basin by the Lits Coquilliers. Beds of the same age are well exposed in the Isle of Wight.

Bainbergs (*Arm.*) Extra defences for the shin, made of iron or leather, and buckled over chain armour. Superseded eventually by greaves.

Baize. A coarse woollen material with a long nap, manufactured in Yorkshire.

Baked (*Typog.*) Said of type when caked together and hard to distribute.

Bakehouses (*Hygiene*). The Factory and Workshop Act, 1901, contains a long series of enactments for sanitary regulation of bakehouses. This regulation is a matter of considerable importance, not only on account of the large number of men employed in the trade, but also on account of the importance of bread as an article of food. An underground bakehouse cannot be used as such (Section 101) now unless the sanitary authority certifies that it is suitable as regards construction, light, ventilation, and all other respects.

Baking (*Pot.*) Firing the objects made of clay, which would otherwise fall to pieces when dry. *See* BISQUE OVEN, GLOST OVEN, ENAMEL KILN, ETC.

Baking Powder (*Hygiene*). Generally a mixture of bicarbonate of soda, tartaric acid, and some form of starch. When this mixture is moistened it gives off a quantity of carbonic acid gas, which aërates the bread and makes it light.

Bala Beds (*Geol.*) Rocks of Upper Ordovician age, typically developed in the Bala district of North Wales. They include rocks of both sedimentary and volcanic origin. In the typical district they are richly fossiliferous, and these fossils include

a great variety of graptolites, which occur in dark shales in deep water. An extensive suite of Brachiopoda and Trilobites is found in the other types of sediments.

Balance (*Physics, Chem., etc.*) A delicately poised beam or lever of the first kind, with equal arms, constructed so that the centre of gravity of the beam lies below the level of the fulcrum. From the ends of the beam hang the scale pans, supported by slings which turn on knife edges, so that they always hang vertically. *See also* SPRING BALANCE.

—— (*Paint.*) General harmony in a picture.

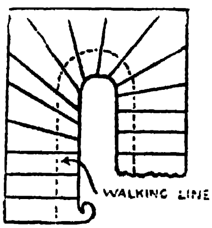
—— (*Watches*). The "fly wheel" of a watch, chronometer, or portable clock.

Balance Box (*Eng.*) A box containing the weights used to counterpoise a balance crane (*q.v.*)

Balance Crane (*Eng*) *See* CRANES.

Balance Cylinder (*Eng.*) A small cylinder containing a piston attached to the valve rod of a large vertical engine to neutralise the weight of the valve and rods, and hence to render the valve easier to move. The weight of the main piston is also balanced in the same way in some engines.

Balanced Steps (*Carp.*) The method of arranging the steps of geometrical stairs to increase the going (width) at the small ends of the winders, and to give a better falling line to the handrail.



BALANCED STEPS.

Balance Gear (*Motor Cars*). *See* DIFFERENTIAL GEAR.

Balance Spring *or* **Hair Spring** (*Watchmaking*). An elastic spring attached by one end to the collet of the balance, the other end being fastened to the stud on a fixed part of the movement. Its use is to restore the balance wheel to its position of rest after it has been displaced. *See also* BALANCE *and* BALANCE WHEEL.

Balance Weight (*Eng.*) A weight used to balance moving parts when running (*see* BALANCING) or merely to render some portion of a machine easier to move by hand, or to relieve any structure of undue stresses. An example occurs in the balance crane (*q.v.*)

Balance Wheel (*Clocks and Watches*). The regulating wheel of a watch or chronometer, whose alternate movement in opposite directions fulfils the function of a pendulum. It constantly tends to return to a fixed position of rest under the influence of a spiral spring attached to its axis (the balance spring or hair spring).

Balancing of Machinery. The adjustment of the moving parts so that the forces on the bearings, axles, etc., due to the movement, remain as nearly constant as possible. Thus a rapidly rotating wheel is properly balanced when it is absolutely symmetrical about its axis of rotation. Any unsymmetrical portion (*e.g.* a crank pin) must be compensated by the addition of a suitably adjusted counterpoise weight on the opposite side of the centre. A truly balanced machine should run without vibration or rocking when freely suspended in the air by chains or other means, and this test can actually be applied to many pieces of mechanism.

Balas Ruby (*Min.*) The rose-coloured variety of SPINEL (*q.v.*) Used as a gem.

Balata (*Botany*). ***Mimusops palata*** **(order,** ***Sapotaceæ*****).** A guttapercha from the stem of the Brazilian milk tree. It was introduced to replace the ordinary guttapercha.

Baldachino, Baldachin, or **Baldaquin** (*Architect.*) A canopy. Generally used to denote the canopy over an altar, which is usually supported on columns, but occasionally suspended from the ceiling. Also known as the CIBORIUM and as the TABERNACLE.

Baldric (*Cost.*) (1) A shoulder-belt, whence baldric-wise, worn across one shoulder and under the opposite arm. Generally used to suspend weapons. (2) The leather by which the clapper of a bell was at one time suspended. In old churchwarden accounts the term frequently recurs, as use soon wore out the leather, necessitating renewal.

Baldwin's Phosphorus. Calcium nitrate. Called Baldwin's Phosphorus because Baldwin observed that when heated it becomes phosphorescent, though it has no relation whatever to phosphorus.

Bale Breaker (*Cotton Spinning*). A machine used in the blowing room for loosening the matted fibres in the compressed bale. There are two kinds: (1) the spiked roller; (2) hopper feed.

Balk (*Eng., Carp., etc.*) A log of timber roughly squared up by the axe.

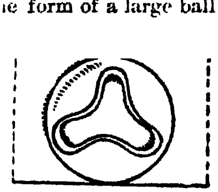
Ball (*Metallurgy*). The mass of spongy wrought iron collected from the puddling furnace (*q.v.*) ready for hammering to expel slag and consolidate the iron.

Ballast (*Eng.*) The loose material laid on the surface of a permanent way (*q.v.*) to steady the sleepers and to help the drainage of the line. Usually broken slag, cinder, stone, etc., of a depth of 18 in. Also the material placed in empty cargo vessels to sink the hull to a depth necessary to ensure stability.

Ball Bearings (*Cycles, Cars, etc.*) Any bearing in which the bearing surfaces are separated by small hardened steel spheres, turned very true. Frequently the bearing surfaces form a hollow and a solid cone with the balls between them; or the balls run in a channel of hemispherical section termed a "ball race." *See also* CYCLES.

Balled Warp (*Cotton Weaving*). A warp or number of threads coiled in the form of a large ball for easy transit and handling.

Ball Flower (*Architect.*) A small ornament of spherical shape used at intervals in a hollow moulding. It was used freely in Decorated Gothic work, and occasionally in the Early English period.


BALL FLOWER.

Balling, Balling Up (*Metallurgy*). The formation of the ball of puddled iron (*q.v.*)

Ballistic Pendulum (*Phys., Mechanics*). A heavy pendulum, with a bob adapted to receive and retain a projectile fired into it. By observing the vertical distance the bob rises, and knowing its weight we obtain the kinetic energy of the projectile, and hence its velocity at the moment of impact. A modified form of ballistic pendulum is also used for experiments on falling bodies.

Ball Joint (*Eng.*) A joint in which one member forms a part of a sphere fitting a corresponding hollow in the other; it allows play in all directions except along the axis of the two members.

Ballooning (*Cotton Spinning*). A defect in ring spinning caused by the high velocity of the ring traveller. This has the effect of causing the spun thread to fly outwards as it winds round the bobbin. Guards are fixed to counteract this, of which there are several kinds.

—— (*Eng.*) The lifting of the sediment in a steam boiler by the action of the steam.

Ball Pane. *See* HAMMERS.

Ball Race. *See* BALL BEARINGS.

Ball Valve (*Eng.*) A valve in the form of a sphere. It can turn round in its seat, thus securing more uniform wear.

—— (*Plumb.*) A cock used for supplying water to cisterns, governed by a hollow ball, fixed to the end of a lever. As the water rises above a given level, the ball raises the lever and closes the tap, the falling of the water level opening it again. The cistern is thus kept filled to a constant level.

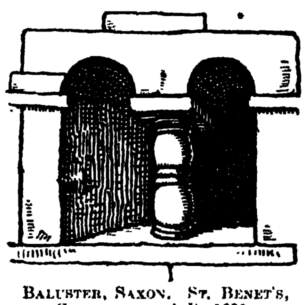
Balsam of Peru. *Toluifera* (*Myroxylon*) *pereiræ* (order, *Leguminosæ*). An exudation from the stem after removal of the bark. Used medicinally. *See also* BALSAMS.

Balsam of Tolu. *Toluifera* (*Myroxylon*) *punctata* (order, *Leguminosæ*). A balsam obtained by incision of the bark. It is used in medicine. *See also* BALSAMS.

Balsams. Exudations from certain plants; they contain benzoic or cinnamic acid or both, a volatile oil, generally a benzoic or cinnamic ester, and a resin. Most important balsams are gum benzoin, containing much benzoic acid (*q.v.*), Balsam of Peru, Balsam of Tolu, and Storax, which contains Styrene, $C_6H_5CH : CH_2$. They are reddish-brown solid or semi-solid substances, insoluble in water, but soluble in alcohol.

Balteus, *pl.* **Baltea** (*Cost.*) The shoulder belt used by the Romans, and from which hung the sword along the left hip.

Baluster (*Architect.*) (1) A kind of small column used in a series, with a capping, to form a protective fence. (2) A roughly formed mid-wall shaft used in belfry windows in Saxon architecture. (3) The return part of the Ionic volute. *See* ANGLO-SAXON *and* BOLSTER.



BALUSTER, SAXON. ST. BENET'S, CAMBRIDGE. A.D. 1000.

—— (*Carp.*) A slender column supporting the handrail and connecting it with the stairs or landing.

Balustrade (*Architect.*) A series of balusters, upon which a capping rests, either forming a protecting fence or employed merely as an ornament.

—— (*Carp. and Join.*) A row of balusters capped by a handrail.

Bambocciata (*Paint.*) A representation of rustic or grotesque scenes not always of the highest order. Bamboccio (a dolt) was the nickname of Pier van Laer, who painted many of these scenes. Teniers and Van Ostade have also painted similar pictures.

Bamboo. *Bambusa* (order, *Gramineæ*). This extensive genus of giant grasses has many economic uses, particularly in the East, where they furnish material for building and for every domestic use.

Bamboo Frames (*Cycles*). Bamboo rods have been used to replace metal tubes in cycle frames, for the sake of lightness, but are not likely to become general. The lugs are sometimes made of aluminium.

Banana. *Musa sapientum* (order, *Musaceæ*). The seedless fruits of one of the most valuable food plants known. The fibres of the stem and leaf stalks are used for cordage.

Banca Tin *or* **Straits Tin** (*Met.*) A pure ore from Malacca and Banca; the best tin found.

Band (*Architect.*) A flat member or moulding larger than a fillet, but smaller than a fascia. In Gothic architecture, a flat moulding or a series of ornaments forming a string course.

—— (*Cost.*) The collar which succeeded the uncomfortable ruff. It still survives as part of a conventional dress, whether academical, ecclesiastical, or legal, and is now termed bands. "Band-box" was formerly the light box in which bands were kept.

—— (*Eng., etc.*) A flat driving belt; also applied to any thin strap of metal or other material fixed round the circumference of an object.

Band Brake (*Eng., Motor Cars, etc.*) A band of steel (sometimes with wood blocks along its inner side) fitting round a drum on the shaft; one end is fixed to the frame of the machine, the other to a lever by which it can be drawn tightly round the drum to check its rotation. Band brakes are much used on motor cars.

Banded (*Her.*) When the tie or fillet which binds a sheaf of corn or arrows is of a different tincture from the sheaf, the sheaf is said to be "banded of that tincture."

Banded Structure (*Geol.*) This term is merely descriptive of an appearance in the rock under notice which is due to a parallel arrangement of layers of different character. It is, however, coming into use in a more restricted sense, as descriptive of the parallel structures observable in gneisses, which are due to alternate folia of different mineral composition.

Banderolle, Banner Roll (*Her, etc.*) (1) The small streamer which hung from the crook of a crosier, and was generally wound round the staff; (2) flags about 3 ft. square carried at funerals; (3) long bands used in scrollwork, etc.; (4) the streamers from a lance.

Bandoleer *or* **Bandolier** (*Cost.*) A shoulder belt with loops in which cartridges are carried.

Bands (*Bind.*) The cords to which the sheets of a volume are sewn. In *flexible* sewing the bands appear in the back, but when the sewing is so executed that the cords are imbedded in the back, the appearance of raised bands is obtained by glueing strips of leather across the back before binding.

—— *See* BAND (*Cost.*)

Band Saw (*Carp., Eng.*) A thin, flexible, ribbon-like saw, with its ends brazed together, and driven over revolving pulleys, between which is a table for the work, with a slit for the saw. Used chiefly for wood, but sometimes for metal.

Banjo. *See* MUSICAL INSTRUMENTS: STRING.

Banjo Frame (*Eng.*) A short connecting rod made of several bars joined in a kite-shaped frame.

Bank (*Typog.*) A table or bench on which sheets are placed as printed.

Banker (*Building*). A mason's or plasterer's bench.

Banking of Cycle Tracks (*Cycles*). The raising of the outer edge of a bend in the track to counteract the centrifugal force, which would otherwise carry the machine off the track when trying to turn round a bend.

Banking Up (*Eng.*) Covering a bright fire in a boiler with a closely beaten mass of small coal, to secure slow combustion when little or no steam has to be produced.

Banner (*Her.*) A large flag, square in shape, on which was a coat of arms or device. One edge was attached either to the staff or to a rod pendant from the top of the staff.

Baptistery (*Architect.*) A building, or part of a building, in which the rite of baptism is or was administered. In Early Christian churches the baptistery was a separate building kept quite distinct from the basilica (*q.v.*)

Bar (*Eng., etc.*) Usually a rod of metal of various forms of cross section. Also applied to many parts of finished structures or machines.

—— (*Her.*) A diminutive of the fesse; it only occupies one-fifth of the field. It is horizontal.

—— (*Lace Manufacture*). A term applied to most of the longer parts of a lace machine, but when used without a prefix generally means the steel or guide bars—thin ribbons of steel with holes or perforations at certain accurate intervals.

—— (*Marine*). A bank or ridge across the mouth of a harbour or inlet; not necessarily reaching the surface at any point, but sufficiently near to impede navigation.

—— (*Music*). (1) A perpendicular line drawn across the stave, immediately before the strong accent; (2) a measure of music contained between two perpendicular lines across the stave.

Bar Armature (*Elect. Eng.*) A large armature in which the windings are built up of copper bars instead of continuous wire, which would have to be of too large a size to be convenient. The connections to the commutator and between different bars are made by copper strips of suitable shape, attached to the bars by well made soldered joints. In the case of alternating current motors the rotating portion is often constructed in a somewhat similar manner, but the connections between the ends of the bars are much simpler. *See* MONOPHASE *and* POLYPHASE MOTORS.

Barbadoes Tar *or* **Jew's Pitch.** The mineral pitch imported from Barbadoes; from it is made black varnish. *See also* BITUMENS.

Barbe (*Cost.*) Piece of white plaited linen passing either over or under the chin, according to the rank of the lady wearing it. Was generally worn by widows, and still worn by nuns.

Barbotine (*Pot.*) Kaolin clay worked into a paste or slip from which objects can be moulded. Used for the decoration of pottery. Sometimes used for the vases, etc., so ornamented.

Barded (*Her.*) A horse covered with armour is said to be "barded."

Bare (*Eng.*) A term somewhat loosely used to indicate a dimension somewhat smaller than its nominal size; the expression should be avoided when possible.

Bareface Tenon (*Carp. and Join.*) A tenon with shoulder on one side only. *See* TENON.

Barff's Process (*Eng.*) Iron protected from ordinary red rust by heating to redness and exposing it to steam, thus producing a coat of the so-called magnetic oxide of iron, Fe_3O_4.

Barge Boards (*Carp.*) The boards fixed at the gable end of a roof, forming a lining between the roofing material proper and the interior.

Barge Course (*Building*). The row of tiles or slates over the gable.

Baritone (*Music*). (1) A male voice between a bass and tenor; (2) a brass instrument. *See* MUSICAL INSTRUMENTS: SAXHORN.

Barium, Ba. Atomic weight, 137·4. A silvery white metal which rapidly oxidises in air and decomposes water. To obtain it a solution of barium chloride is electrolysed with a mercury kathode, and the barium amalgam so obtained is heated in a porcelain tube by means of a platinum wire kept at a temperature of about 1150° by an electric current. The mercury volatilises first, and then the barium, which is nearly pure. Barium does not occur native, but in combination it exists in many minerals—*e.g.* BARYTES, WITHERITE, BARYTO CALCITE, ALSTONITE (*q.v.*), etc., etc.

Barium Compounds. BARIUM OXIDES, BaO, obtained by carefully heating the nitrate, is a white solid having the properties of a typical basic oxide (*see* OXIDES). Combines with evolution of much heat with water to form BARIUM HYDROXIDE, $Ba(OH)_2$, a white powder more soluble in water than slaked lime; the solution is called BARYTA WATER. BARIUM DIOXIDE, BaO_2, is produced by heating the monoxide in air or oxygen. It is a typical peroxide (*see* OXIDES *and* BRIN'S PROCESS). BARIUM SULPHATE, $BaSO_4$, is an insoluble white powder, and the chief source of barium compounds. Heated with charcoal it forms BARIUM SULPHIDE, BaS, a white solid which dissolves in dilute acids, forming the corresponding salt and sulphuretted hydrogen (*see also* BOLOGNIAN PHOSPHORUS, BARYTES, *and* BLANC FIXE). BARIUM CHLORIDE, $BaCl_2 2H_2O$, a white crystalline solid which may be obtained from the sulphate as indicated above; its solution is used as a test for soluble sulphates, which form with it the insoluble barium sulphate. BARIUM NITRATE, $Ba(NO_3)_2$, a white crystalline solid used in making "green fire," and also as a test for sulphate; may be obtained from the sulphate as indicated above. The soluble barium compounds are poisonous. *See also* BARYTES.

Bark (*Botany*). The dead tissue formed on the outside of the cork cambium. It often contains waste products, alkaloids, tannin, resins, etc., and consequently is of great economic value.

Bar Lathe (*Eng.*) A small lathe whose bed consists of a single bar of triangular or rectangular section.

Barley. *Hordeum vulgare* (order, *Gramineæ*). Several varieties of the species are cultivated; the two-rowed barley is the most common, while the six-rowed variety (known as *Bere* or *Bigg*) is more grown in Scotland. The hardiest is the four-rowed barley. Barley grain consists of four envelopes. The presence or absence of the husk determines the commercial preparations. Barley meal is prepared from the whole grain; pearl barley (which is used in making barley water), Scotch and milled barley are deprived of the husks. Cakes made from barley are found to be of less nutritive value than those made from wheat.

Barlow's Wheel (*Elect.*) A copper disc pivoted between the poles of a permanent magnet. If a current be caused to flow along a radius of the disc, the latter rotates; if the disc be rotated by mechanical means, a current is set up. The instrument thus acts either as a motor or a dynamo. The plane of the wheel and the direction of the current are at right angles to the plane of the magnet; thus the lines of force, the current, and the direction of motion are mutually at right angles.

Barmen Machine (*Lace Manufac.*) So named from "Barmen" in Germany, where it is principally made. It is a development of the "dolly" or braiding machine, and produces a clever imitation of "Torchon" lace. In its latest improved form the production can scarcely be distinguished from the "real" article. Manufacturing centres, Barmen and Nottingham.

Bar Mill (*Eng.*) Rolling mill for producing bars of iron or steel.

Barograph (*Phys., etc.*) An instrument for continuously recording the height of the barometer. In the simplest form the levers of an aneroid (*see* BAROMETERS) mark the height of the barometer (*i.e.* the atmospheric pressure) upon a rotating drum; when a mercurial barometer is used, a strip of sensitised paper may be drawn slowly past the top of the mercury, and a line will be left showing the boundary of the shadow which marked the height of the mercurial column at each instant.

Barometer. A barometer is an instrument used for measuring the pressure of the air. The simplest form is shown in fig. 1. It consists of a vertical tube something over 30 in. high, closed at the top. This is filled with mercury and inverted with its open end under the surface of mercury contained in a shallow vessel, A. The mercury in the tube falls to a height AB, which is usually between 28 and 30 in., according to the pressure of the air. The space above B in a properly constructed barometer is a very perfect vacuum, and is usually termed the Torricellian Vacuum, after its discoverer. A more convenient form of barometer consists of a tube bent into the form shown in fig. 2, termed the Syphon Barometer. The tube is first completely filled with mercury and then placed in a vertical position, the superfluous mercury being allowed to flow out at D. The vertical height between the levels of the mercury at A and B is in this case the height of the barometer. It is necessary to note that in this case a fall of half an inch at B will be accompanied by a rise of half an inch at A, and therefore the total height will have been diminished by 1 in. If, then, a fixed scale is attached to the longer tube, it will have to be divided into half inches, and each half inch numbered as if it were 1 in. In many cases a small float rests on the surface of the mercury at A, and a cord attached to this float turns a revolving pointer, which indicates the height of the barometer on a graduated dial. For accurate work a modified form of the cistern barometer devised by Fortin is frequently used. In this barometer the level of the mercury in the cistern is first adjusted to a constant level. The means of doing this are shown in fig. 3. The barometer tube A passes into a cistern (B), of which the upper part is of glass. The mercury in this cistern is retained by a false bottom, formed by a flexible sheet of leather (C), attached to a ring (F). This flexible bottom can be moved up and down by a set screw (D), which passes out at the bottom of the cistern. The level of the mercury in the cistern is raised or lowered by turning the screw D until an ivory point E exactly touches the surface. When this is the case a fixed scale on the tube A gives the exact height of the mercury in the tube above the level of the mercury in the cistern. The mercurial barometer is not suited for any purpose where portability is required, and a different principle is used in what is called the "Aneroid" barometer. This principle is illustrated diagrammatically in fig. 4. A shallow metal vessel (A) is closed by a thin corrugated top of flexible metal (B), and is exhausted of air. An increase in the pressure of the air will compress the flexible top B inwards, and a diminution in the pressure will cause it to spring out. The movements of B are rendered visible by means of a lever (D) attached to its centre in the manner shown in the diagram.—CORRECTIONS OF THE BAROMETER READING: Both the mercury in the barometer and the material of which the scale is composed are liable to expansion and contraction by changes in the temperature of the air, and for this reason readings are reduced to their value at 0° C. in the case of accurate observations. The following formula for reducing the observations is proved in works on heat:

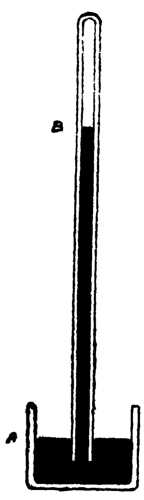


FIG. 1. SIMPLE F.

FIG. 2. SYPHON BAROMETER.

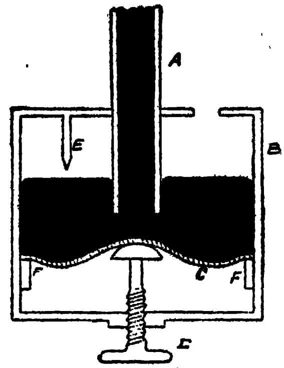


FIG. 3.—FORTIN'S BAROMETER (CISTERN ONLY).

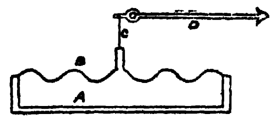


FIG. 4.—ANEROID.

H = the true height of a barometer at 0°.
h_t = the observed height at a temperature t.
δ = the coefficient of cubical expansion of mercury.
α = the coefficient of linear expansion of the material of the scale.

Then

$$H = h_t \left\{ 1 - (\delta - \alpha)\, t \right\}.$$

For a barometer with a brass scale, taking the usual values of α and δ, this formula becomes

$$H = h\ (1 - {\cdot}000162t).$$

Barometer Corrections (*Phys.*) *See* BAROMETER

Barometer, Mercurial (*Phys.*) *See* BAROMETER.

Baroque (*Art.*) Ornamentation that is grotesque or in bad form.

—— (*Architect.*) *See* RENAISSANCE ARCHITECTURE.

Barrathea (*Woollen Manufac.*) Small fancy weave of a broken mat type applied to dress and coating fabrics of this name.

Barrel (*Building*). (1) Iron piping used for gas or water; (2) the cylinder in which the piston of a pump works.

—— (*Eng., etc.*) The cylindrical part of many structures—*e.g.* the body of a pump, locomotive boiler, rifle, or gun. Also the part of a machine on which a rope or chain is wound, either on the surface or in specially cut grooves.

—— (*Watches*). The cylindrical box containing the mainspring.

Barrel Vault (*Architect.*) A vault of semicircular cross section. It is the simplest kind of vault used to cover a rectangular space. It was used by the Romans and also by the Romanesque architects.

Barrier Pillars (*Mining*). The largest pillars left to support the roof in a mine.

Barrow (*Archæol.*) An artificial hillock or mound heaped over the graves of presumably notable individuals in prehistoric times.

Barrulet (*Her.*) Is one-fourth the width of the *bar*, and occupies one-twentieth of the field.

Barruly (*Her.*) Said of a shield traversed by more than eight bars.

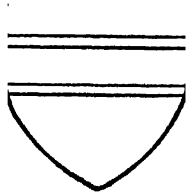
Barry (*Her.*) A shield divided into an even number of bars.

Barry Bendy (*Her.*) The lines dividing the shield are drawn both barwise and bendwise.

Barry Pily (*Her.*) The lines are drawn barwise (*i.e.* horizontally), and then divided into an equal number of piles or wedge-shaped pieces of alternate tinctures.

Barry Wavy (*Her.*) When the horizontal lines are wavy and not straight.

Bars Gemelles (*Her.*) Barrulets in couples.



BARS GEMELLES.

Bar Solder (*Plumb.*) Plumbers' solder, composed of two parts of lead to one of tin, cast in the form of bars, and used for wiping joints.

Bar Stays (*Eng.*) Rods used to strengthen a boiler; so called to distinguish them from stays which are also tubes, through which water circulates.

Bar Timbering (*Mining*). Supports for the roof of a level, etc., while the material below is excavated and the permanent supports (masonry, etc.) are being put in.

Bartizan (*Architect.*) A small turret projecting beyond the face of the main building.

Bartonian Series (*Geol.*) A name used for the MIDDLE EOCENE strata of the same age as the fossiliferous clay seen in the coast at Barton, in Hampshire. This is a marine deposit containing an abundant suite of fossils, chiefly of types analogous to those animals which at the present day frequent the seas of sub-tropical regions.

Bar Tracery (*Architect.*) The form of window tracery used in Gothic work after the early part of the Decorated period. In this kind of tracery the mullions are carried up into the head of the window, and have the appearance of having been bent to the required shape. *See* TRACERY, PLATE TRACERY, *and* FLAMBOYANT TRACERY.

Bar Trees (*Woollen Manufac.*). *See* WOOF.

Baryta. A common name for barium monoxide. When the latter is shaken with water the solution of barium hydroxide so obtained is called baryta water.

Barytes (*Min.*) Barium sulphate, $BaSO_4$; baryta = 65·7; sulphuric acid = 34·3 per cent. It crystallises in a great variety of forms of the rhombic system. It is one of the most insoluble minerals; colourless or variously tinted. It is used largely in the manufacture of permanent white and for admixture with white lead and in the manufacture of paper for process printing. For these purposes pure barytes is in much demand. When stained by ferric hydrate, the mineral has to be treated with sulphuric acid before crushing. It is an important gangue metal, often being found in lead-bearing veins. Some of the best known localities are Silvera Band Mine near Milburn, Rundale Mines near Dufton in Westmorland, Whitehaven in Cumberland, Wanlockhead in Dumfriesshire, etc.

Baryto Calcite (*Min.*) A combination of the carbonates of calcium and barium crystallising in monosymmetric prisms. $BaCO_3 . CaCO_3$. barium carbonate = 66·3; calcium carbonate = 33·7 per cent. Usually white or pale yellow. Found near Nenthead on Alston Moor, and at Wall, near Hexham.

Basal (*Min.*) A term used to designate a plane parallel to or coincident with a face normal (or at right angles) to the principal axis of a crystal. Thus the basal cleavage of barytes is a cleavage parallel to the basal face, which is itself normal to the principal axis.

Basalt (*Geol.*) A hemicrystalline rock of basic composition which contains, besides the glassy or lithoidal ground mass, crystals of a lime soda felspar (which is usually Labradorite), AUGITE (or some other pyroxene), OLIVINE, and ILMENITE. It forms lavas and also dykes and sills. It is usually a dark-coloured, heavy rock, which weathers with a more or less ferruginous crust.

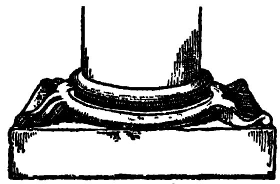
—— (*Archæol.*) This stone was used by the Egyptians for sculpture and building. *See also* BUILDING STONES.

Basalt Glass *or* **Tachylite** (*Geol.*) A somewhat rare native glass of basic composition, corresponding to the PITCHSTONES amongst the rocks of intermediate composition and to the OBSIDIANS in the acid series. The glass is due to the rapid cooling of the magma from which the basalt arises, generally where it comes into contact with the colder surface of the rock adjacent. It appears to devitrify more rapidly than the other native glasses.

Bascinet, Basinet, Basnet (*Armour*). A helmet, somewhat globular in shape, but terminating in a point, worn during the Camail period. It was fastened by a lace passing through the edge of the helmet and protected by plates of metal. It had no visor at first, the "heaume" being worn over it for battle and at jousts.

Bascule Bridge (*Civil Eng.*) A swing bridge of the "seesaw" type. The Tower Bridge, in London, is one of the best examples.

Base (*Architect.*) (1) The lower portion of a pier or wall. (2) That part of a column on which the shaft rests. In the Greek-Doric order no base is used, however, the shaft resting directly on the stylobate.


BASE, EARLY ENGLISH.

—— (*Dec.*) The material which is mixed with the oil to give body to paints. The most common bases are white lead, red lead, zinc white, and oxide of iron.

Base Line (*Surveying*). (1) An accurately measured line from which a triangulation is started or offsets are measured. (2) The main lines of a traverse (*q.v.*)

Base Moulding (*Architect.*) A moulding near the base of a wall, either just at the top of the plinth or a short distance above it.

Base Plate (*Eng., etc.*) The lowest part of a machine; a structure to which the remaining parts are directly or indirectly fixed. In large machines it is usually an iron casting with suitable projections, to which the superincumbent portions of the structure can be fixed.

Basic Dyes. Dyes which in order to fix them upon a fabric are required to be combined with a substance of acid character; *e.g.* rosaniline will dye cotton when tannic acid is used as mordant, but it will dye wool or silk directly, probably because wool and silk contain some acid as a constituent of their fibres. *See also* DYES AND DYEING.

Basicity. A term used to express the number of hydrogen atoms in the molecule of an acid that can be replaced *by metals.* A *monobasic acid* has one replaceable hydrogen atom, a *dibasic acid* has two, and so on; *e.g.* nitric acid has one replaceable hydrogen atom, and is monobasic; citric acid, $C_6H_8O_7$, has three replaceable hydrogen atoms, and is tribasic.

—— (*Met.*) The power of acting as a "base" in the chemical sense. In metallurgy it refers especially to the absence of silica, which has the opposite or "acid" character.

Basic Lavas (*Geol.*) Rocks which have been poured out at the surface from volcanic orifices, and which contain a low percentage of silica—generally less than 50. They include rocks of somewhat varied composition and character, of which ordinary basalt may be regarded as a central type.

Basic Oxide. *See* OXIDES.

Basic Process (*Metallurgy*). An improvement of the Bessemer steel process (*q.v.*) in which the converter is lined with magnesian limestone or dolomite, a material nearly free from silica. This removes the phosphorus and silica, which are very detrimental to the iron even in small quantities, and, moreover, yields a "basic slag" rich in phosphorus, and of considerable value in agriculture for enriching soil, as phosphates are essential to the proper growth of most plants.

Basic Salt. A normal salt (*see* SALTS) combined with the basic oxide corresponding to it; *e.g.* basic lead acetate is $PbO.Pb(C_2H_3O_2)_2$; basic bismuth nitrate is $BiONO_3$, which may be regarded as $Bi_2O_3 . Bi(NO_3)_3 = 3(BiONO_3)$.

Basic Steel (*Met.*) Steel produced by the basic process (*q.v.*)

Basilica (*Architect.*) The Roman name for a hall, either of justice or in which business was conducted. Roman basilicas were in many cases adapted for use as Christian churches, and the new Early Christian churches were built on similar lines. The basilica generally consisted of a nave with aisles, galleries over the aisles, and a semicircular apse at one end. The term basilica was originally used to denote a king's palace. *See* APSE, NAVE, *and* AISLES.

Basilidian Gems. *See* ABRAXAS.

Basilisk (*Archæol.*) A mythical reptile, also termed cockatrice, hatched by a serpent from a cock's egg. Its breath and its gaze were alike fatal. Symbolical of the spirit of evil.

—— A large brass cannon, formerly in use, throwing a shot of about 200 lb.

Basin (*Civil Eng.*) An enclosure or dock with quays, into which vessels can be admitted at high tide, the water being then retained at the same level by dock gates. Used for loading and discharging ships.

—— (*Geol.*) A SYNCLINAL (*q.v.*)

Basket (*Eng., etc.*) A strainer attached to the foot pipe of pumps to exclude solid bodies. Also applied to the aggregate of parallel rods in certain type-writing machines, and to devices of similar appearance in other machines.

Basking Shark. *Cetorhinus maximus* (family, *Carchariidæ*). A large shark found in the North Atlantic, and hunted for the sake of the oil extracted from its liver (shark oil).

Bas Relief *or* **Basso Relievo** (*Architect.*) Sculpture in which the figures project less than half their proper proportion from the background. One of the finest examples is the frieze on the cella of the Parthenon, of which a considerable portion is now in the British Museum among the Elgin marbles. *See* ALTO RELIEVO, MEZZO RELIEVO, CAVO RELIEVO, *and* INTAGLIO.

Bass (*Botany*). *Leopoldinia piassaba* (order, *Palmæ*). The persistent leaf bases end in tufts of bristle-like fibres, which constitute the bass or *piassaba* fibre used in making bass brooms. The bass from Bahia is obtained from another palm (*Attalea funifera*). *See also* WOODS.

—— (*Music*). (1) The lowest of men's voices. (2) The lower series of sounds. (3) The lowest note of a chord.

Bass Drum. *See* MUSICAL INSTRUMENTS: PERCUSSION, INDEFINITE SOUND.

Bassoon. *See* MUSICAL INSTRUMENTS: WIND, WOOD.

Bass Tuba. *See* MUSICAL INSTRUMENTS: WIND, BRASS.

Bass Wood. *See* WOODS.

Bast (*Botany*). The soft bast or phloem is the tissue on the outer face of the wood of a vascular bundle; it consists of sieve tubes (*q.v.*) and other elements.

Bastard Cop (*Cotton Spinning*). *See* COP.

Bastard Cut (*Eng.*) A coarse file, slightly finer than the most coarse kind.

Bastard Flatting (*Dec.*) Painted work finished only with a slight gloss, produced by using less oil and more turpentine than is employed in ordinary

oil paint. Three-fourths turpentine and one-fourth boiled oil is the proportion often employed. Also termed "eggshell gloss." Bastard flatting makes a good ground for work that is to be finished in varnish or enamel.

Bastard Founts (*Typog.*) Type cast on a body larger or smaller than is usual.

Bastard Thread (*Eng.*) An old expression for a screw not of standard pitch.

Bastard Title (*Typog.*) An abbreviated or half-title on a page preceding the full title page of a book.

Bastard Tuck (*Building*). The name given to POINTING (*q.v.*) when a small projection of the stopping itself is formed on the joint.

Basterna (*Archæol.*) A mule litter used chiefly by ladies during the period of the Roman Empire.

Bast Fibres (*Botany*). The term is applied to strands of lignified fibres (belonging to the pericycle) on the outside of a vascular bundle. The fibres usually have a tensile strength equal to that of the best wrought iron or hammered steel, while their ductility is ten times as great as that of iron.

Bat (*Building*). Half a brick—*i.e.* a piece $4\frac{1}{2}$ in. long.

Batement Light (*Architect.*) A window having vertical jambs and mullions and a sloping sill.

Bath (*Eng., etc.*) A vessel containing liquid, frequently liquid metal. Also applied to the liquid itself, or even to the process of dipping some object in course of manufacture into the liquid.

Bathing (*Hygiene*). Is of hygienic importance. The skin should be kept thoroughly clean, otherwise dead epidermic cells collect, and prevent the proper physiological action of the glands in the skin, thereby throwing extra work on the kidneys and lungs. A bath is best taken in the early morning. It should never be taken immediately after a full meal.

Bath Stone. *See* BUILDING STONES.

Baths, Waste from (*Hygiene*). It is of great importance that the waste-pipes from baths should not be connected with the drains. They should be efficiently trapped, and be made to discharge into a properly trapped gully. The overflow pipe should discharge into the open air. Baths should not be cased in, as this form of fixing accumulates dust.

Bating (*Leather Manufac.*) A bate consists of a fermenting solution of hen or pigeon excrement into which light skins for "dressing" leather are placed to soften and remove lime. The action is largely bacteriological. The process is being gradually superseded by safer and less objectionable methods.

Baton (*Her.*) A diminutive of the bend sinister, of which it is one-fourth the width, and couped at the ends—*i.e.* not touching the edges of the shield. It is used as an abatement, and is generally known as the bar sinister.

—— (*Music*). The conductor's stick for beating time.

Bat's Wing (*Gas Fitting*). A gas burner with a slit giving a flat flame.

Batten (*Carp.*) A piece of wood from 2 to 7 in. wide and up to $2\frac{1}{2}$ in. thick.

—— (*Woollen Manufac.*) French term for going past the portion of the loom for carrying the reed or sley and shuttle race, and for beating "home" the weft yarn. Also applied to the frame mounted with the card cylinder in the Jacquard loom.

Batten Door (*Carp. and Join.*) A door having vertical boards about 3 in. wide in the place of panels. They may be ledged only, or ledged and braced.

Battened Wall (*Carp.*) A wall having pieces of wood (battens) fixed to it to nail matchboarding to, etc.

Batten Lay or Lathe (*Silk Manufac.*) A wooden frame swinging from the loom top, carrying the reed and beating up the weft after each pick. The fly batten has shuttle boxes at each end of the shuttle race, and in a power loom works on a shaft below the warp.

Batter (*Building*). A wall out of perpendicular. Chimney shafts "batter," or slope, about $2\frac{1}{2}$ in. in every 10 ft. of their height.

—— (*Typog.*) Broken or damaged type.

Battery (*Elect.*) (1) A number of primary or secondary cells, condensers, Leyden jars, etc., acting together; (2) often applied, incorrectly, to a single cell. *See* CELLS (PRIMARY) *and* ACCUMULATORS.

—— (*Eng.*) A collection of machines or other plant of a similar character—*e.g.* a number of boilers in the same set, or a number of ore-crushing stamps at a mine.

—— (*Mining*). A bulk head of timber in a gallery or horizontal passage in a mine.

Battle Axe (*Archæol.*) A war weapon varying in shape, size, and material from the stone axe of prehistoric times to the halberd, which was discontinued in the fifteenth century. The axe with an edge on one side and a point on the other was called a pole axe. The axe was the chief weapon of the early Britons.

Battlement (*Architect.*) A parapet used in Gothic work, formed with a series of openings or embrasures, separated by rising parts called merlons. It was originally intended for purposes of defence, but was afterwards constructed as an ornamental feature.

Battle Piece (*Art*). A picture or sculpture representing a scene on a field of battle.

Baudekyn (*Cost.*) A rich material woven from gold thread and silk.

Baumann-Schotten or Schotten-Baumann Reaction. A reaction for the recognition of the amino group ($-NH_2$), imido group ($=NH$), or the hydroxyl group ($-OH$) in organic compounds. A little benzoyl chloride (*q.v.*) is added to the substance, then caustic potash solution till faintly alkaline, and so on till the reaction is completed, gently heating if necessary. In this way a benzoyl derivative is formed—*e.g.* phenol would give $C_6H_5 . OOC . C_6H_5$, phenyl benzoate.

Bauxite (*Min., Met., etc.*) Usually written BEAUXITE (*q.v.*) by mineralogists. Very refractory bricks and slabs for lining furnaces are made by mixing crushed calcined bauxite with clay, or sometimes with graphite.

Bay (*Carp., etc.*) A ceiling or roof divided into panels.

—— (*Eng.*) The spaces in a structure between adjoining stays or struts—*e.g.* the large openings in a lattice girder.

Bayeux Tapestry (*Art*). The well known roll of linen, 200 ft. long by 20 in. wide, preserved at the Town House, Bayeux. It is worked in worsted, and seven colours are used. It depicts fifty-eight scenes in the life of William I.

Bay Salt. Common salt crystallised by slow evaporation. It is a coarse-grained salt, used for curing meat of various kinds.

Bay Window (*Carp. and Join.*) Usually constructed of three lights, which may be "squint" when the sidelights make an obtuse angle with the front, or square when they are at right angles.

Beacon (*Marine*). Any small form of lighthouse constructed on minor shoals. Also a general term for a signal, signal-light, prominent landmark, etc.

Bead (*Architect.*) A small circular moulding. When carved, it usually resembles a string of beads. *See* ASTRAGAL *and* TORUS.

Bead *or* **Beading** (*Carp., etc.*) A linear ornament of uniform cross section used very much in woodwork; to a less extent in metal. Occasionally used to confer strength, but more often for appearance only.

Bead Butt (*Carp. and Join.*) A flush panel with a bead on the vertical edges only.

Bead Flush (*Carp. and Join.*) A flush panel with a bead all round it.

Bead Router. An iron stock in which beading irons of various sizes are fixed. Used in forming a bead on circular work

Beads *or* **Bead Planes.** Planes for "sticking" beads or cutting them out of solid wood.

Bead Sleekers (*Moulding*). A tool used by moulders to finish off a bead in the mould.

Beaked (*Her.*) When the tincture of the beak is different from that of the body.

Beak Head (*Architect.*) An ornament used in Norman work. It was usually carved on the mouldings of a doorway, and took the form of a grotesque head with a beak. *See also* CAT'S HEAD.

BEAK HEAD.

Beak Iron, *or* **Beck Iron.** The conical projection of an anvil. Sometimes "Beckern."

Beam. A beam may be defined as a long bar of wood or metal supported at one or more points, and carrying a load either uniformly distributed or concentrated at various positions. The following terms are used in connection with beams: (1) DEFLECTION—denoted by "d." This is the greatest extent to which any point of the beam is bent by the load which it carries. The following terms are defined under their separate headings: (2) ELASTICITY, denoted by E; (3) BENDING MOMENT, denoted by M; (4) MOMENT OF INERTIA, denoted by I; (5) RADIUS OF CURVATURE, denoted by R; (6) STRESS, denoted by p; (7) NEUTRAL LAYER. If the material of a beam were divided up into thin horizontal layers, it would be found that the uppermost of the layers were in a state of compression, and the lowest layers in a state of tension. These stresses gradually diminish towards a layer of the material of the beam which is, in most cases, at or near the centre (its exact position depends upon the form of the cross-section of the beam; it runs through the "centre of gravity" of the cross-section). This layer is known as the "neutral layer." The distance of any point in the material of the beam above or below the neutral layer is denoted by the letter "y." The above quantities are in all cases connected by the following equation:

$$\frac{P}{y} = \frac{M}{I} = \frac{E}{R}$$

Making use of the equation just given, we are able to calculate the deflection of a beam under any given set of circumstances if we know its dimensions, and the value of the coefficient of electricity (E) for the material of which it is made. The two commonest cases are: (i) A beam of length "l" supported at the ends and carrying a load W at the centre

$$d = \frac{Wl^3}{48\,E\,I}$$

(ii) A beam of length supported at the ends and carrying a load W uniformly distributed over the beam:

$$d = \frac{5}{384} \times \frac{Wl^3}{E\,I}$$

The simplest beams are those of uniform rectangular section; these are most commonly made of wood. Beams of iron or steel are usually made of cross-section in the form of "H"; it is usual to term these iron beams "girders." If the beam is made of cast iron, the lower part, which is in tension, has to be larger than the top part, which is in compression, in order to secure uniform resistance to both stresses; but wrought iron or steel beams have the top and bottom parts the same size. Very large girders are built up of separate pieces at the top and bottom, connected by a central portion or "web," made either of sheets of metal or of numerous bars crossing one another at an angle. A fine example of the latter, known as a "Warren Girder," is to be seen in Charing-Cross railway bridge. The actual calculations involved in designing a beam or girder which is required to carry a given load are somewhat long and complex. They are usually carried out by means of formulæ based on the equations given above. These formulae are given in works on engineering and building construction and in the various pocket books for engineers and builders.

Beam (*Cotton-weaving, etc.*) A flanged roller, similar to a large bobbin, for coiling the warp round in a broad sheet. Used for beam-warper and the loom. *See* BEAMING.

Beam Compass. An instrument for describing circles too large for the ordinary drawing compasses. It consists of a straight bar, on which metal holders for the pencil and compass point can be fixed at right angles to the bar. These holders are called TRAMMELS.

Beam Engine (*Eng.*) A form of engine in which the piston rod was attached to a beam swinging on a central axis; to the other end was attached the pump rod, or connecting rod. Nearly obsolete, except for some pumping engines, but once universal, even being used for marine purposes. *See also* STEAM ENGINES.

Beam Filling (*Building*). The brickwork between the wall plate and the underside of the roof.

Beaming (*Cotton Weaving*). A process in coloured goods manufacture by which the ends that are warped are all run in one broad sheet in their particular pattern on to the weaver's beam. Sometimes adopted in grey manufacturing for running grey-balled warps on to the weaver's beam.

—— (*Woollen Manufac.*) The operation of winding the warp or chain on to the warp-roller or beam, so that each thread will be delivered regularly during weaving.

—— *or* **Turning On** (*Silk Manufac.*) The process of spreading and winding the warp on the cane or warp roll. The warp is placed round a large drum and divided into PORTEES or HALF PORTEES in the teeth of VATOE (*q.v.*); it is then wound on the cane roll, considerable tension being applied to the silk to cause it to pass on to the roll firmly and evenly.

Beams (*Lace Manufac.*) Long slender cylinders of tin plate, in length proportionate to the width of the lace machine. They are requisite where a variable length of material is being used up.

Beam Warping (*Cotton Weaving*). A system of preparing back beams for the SLASHER (*q.v.*) Each beam contains a standard number of threads of a certain length. Used principally for the grey trade.

Bean *or* **Shot Copper** (*Met.*) Copper granulated by pouring through a perforated vessel into water.

Beans. Order, *Leguminosæ*. *Vicia faba* is the broad bean; *Phaseolus vulgaris*, the French bean; *P. multiflorus*, the scarlet runner. Under the name haricots are placed various species of *Phaseolus*. Beans form a very important article of diet; they contain a large quantity of proteids and salts, and are therefore of great nutritive value. During growth and storage beans are attacked by a weevil (beetle), the larva of which may frequently be seen in the bean.

Bear (*Eng.*) A form of punching machine (*q.v.*)

—— (*Zoology*). Genus, *Ursus*; species, *Arctos* (North Europe), *Americanus* (America), *Maritimus*, the Polar bear. The skin affords a useful heavy fur; the flesh is edible, and the fat is frequently utilised as unguent for the hair.

Beard (*Typog.*) That part of the type above and below the face of the letter.

Bearers (*Carp.*) The fillets on which a shelf is fixed. The crosspieces carrying a gutter boarding.

Bearing (*Carp.*, *etc.*) The part of a girder which rests on the supports.

—— (*Eng.*) The support of a rotating shaft; the forms are chiefly distinguished from each other by the means used to diminish friction. *See* BALL BEARINGS, ROLLER BEARINGS, ETC.

—— (*Surveying*). The angle formed by a line with the direction of the magnetic needle.

Bearing Metals (*Eng.*) Alloys used to form the surface of a bearing where the friction occurs—*e.g.* Babbitt's metal, gunmetal, etc. (*q.v.*)

Bearing Piles (*Civil Eng.*) Piles (*q.v.*) driven into soft ground up to their heads, to support masonry or other structures.

Bearing Surface (*Eng.*) The part of a surface in contact with another object and supporting it; in particular, the part of a shaft and bearing which are in contact with each other.

Bearing-Up Stop (*Mining*). A partition used to lead air to a face where work is going on.

Bearing Walls. *See* ARCH.

Beasts, Heraldic. May be recognised at once by their conventional style. The heralds have pressed most animals into use as charges or supporters.

Beater (*Cotton Spinning*). An attachment to an opening or scutching machine, consisting of a shaft on which are fixed blades or wings for the purpose of shaking the cotton when being cleaned. There are several kinds—vertical, conical, porcupine, two-winged, and three-winged.

—— (*Paper Manufac.*) A machine for reducing pulp to a fine state of division.

Beater Roll (*Paper Manufac.*) A heavy iron roll fitted with long iron bars, which rotates in the beater, for disintegrating pulp.

Beating Up (*Cotton Weaving*). The third primary movement of a loom. The forcing or bumping up of weft after it is carried across through the warp by the shuttle. It is accomplished by the loom crank, sley, and reed.

Beats (*Music*). The pulsations of time in a bar, also called "pulses."

Beats (*Sound*). Maxima and minima in the composite sound produced by two notes whose frequencies do not differ by more than sixteen vibrations per second; this result is due to INTERFERENCE (*q.v.*) of the two sets of waves.

Beaumontage. Material used for filling up accidental holes in wood or metal work. In cabinet work, resin and beeswax with colouring matter; in pattern making, chalk and varnish; in iron work, sal ammoniac (ammonium chloride, NH_4Cl), mixed with iron borings, which rust into a solid mass, are used.

Beauxite (*Min.*) An impure aluminium hydrate, essentially $Al_2O_3 . 2H_2O$ with impurities of ferric oxide, phosphates, etc. It occurs in oolitic or clay-like deposits of whitish-brown or reddish-brown colour. From Beaux in France, the United States, Foyers in Scotland, etc. It is now the principal workable ore of aluminium.

Beaver (*Armour*). "In fourteenth century applied to the moveable faceguard of the bascinet (*q.v.*), otherwise called *viziere ventaile* or *avant-taile*. In the early part of the fifteenth century the beaver appears formed of overlapping plates, which can be raised or depressed to any degree desired by the wearer. In the sixteenth century it again became confounded with the vizor, and could be pushed up entirely over the top of the helmet, and drawn down at pleasure."—PLANCHÉ.

—— (*Zoology*). *Castor canadensis* (family, *Castoridæ*). The well known rodent is valued on account of its fur, flesh, and the substance CASTOREUM (*q.v.*)

Beaver Cloth (*Woollen Manufac.*) A thick woollen fabric covered with fibre or nap. The best qualities are made in the West of England; medium and lower qualities in the heavy woollen districts of Yorkshire.

Beaver Finish (*Woollen Manufac.*) A type of finish which gives to the fabric a soft fibrous surface, the fibres being laid, in the process of raising, in one direction. Originally the finish was an imitation of the fur of the beaver.

Bêche-de-Mer (*Zoology*). Class, *Holothuroidea*; sub-kingdom, *Echinodermata*. A group of wormlike marine animals allied to the starfishes. Certain species yield a Chinese food known as TREPANG.

Beck. *See* BEAK IRON.

Beckmann's Apparatus (*Heat.*) *See* FREEZING POINT.

Bed (*Building*). A layer of mortar put under a wall plate, stones, or bricks.

—— (*Typog.*) The level surface or table of a printing press in which the forme lies.

Bed Charge (*Met., Foundry*). The coke which forms the bottom layer in charging a cupola furnace.

Bedder (*Pot.*) A mould, generally made of plaster of Paris, used to impress upon ground flint the exact shape of the clay plate or saucer which is to rest thereon whilst being fired in the bisque oven.

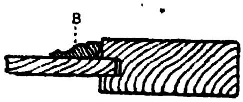
Bedding In (*Moulding*). Moulding by laying the pattern in the sand of the foundry floor and heaping the sand round it, instead of forming the mould in boxes full of sand.

Bedford Cord (*Cotton Manufac.*) A cloth ribbed longitudinally without floats on its surface, and firmly woven.

Bed Joints (*Build.*) (1) The radiating joints of an arch. (2) The horizontal joints of a wall.

Bed Mould (*Architect.*) The moulding immediately under the corona of a classical cornice.

Bed Moulding (*Carp.*) A moulding fixed just below the surface of the framing.



BED MOULDING.

Bed Plate (*Eng.*) *See* BASE PLATE.

Bed Plug (*Build.*) A dowel in the bed joint of a stone.

Bee (*Zoology*). *Apis mellifica* (family, *Apidæ*). The honey bee is well known as the source of honey and wax. *See* BEESWAX, HONEY.

Beech. *See* WOODS.

Beer. A beverage prepared by the fermentation of malt extract by yeast: hops (which contain a bitter principle—lupulin) are added to give the bitter flavour. In place of malt, starch and glucose (artificial) may be used, and in place of hops cheaper substitutes may be used, as quassia, gentian, wormwood. The percentage of alcohol varies from 2 (Berlin white beer) to 8·5 (Scotch ale). Arsenic may be present in beer when made from glucose prepared from starch by means of arsenic containing sulphuric acid. The adulterants of beer are water (which is often added to a considerable extent), salt, sulphuric acid, and liquorice.

—— (*Cotton Weaving*). A term used as a basis for reed counting—*i.e.* twenty dents, or splits, or forty ends, two ends per split. Sometimes a warp during the warping process will be split up into beers or bunches, so as to facilitate counting off. In other cases they are used to assist in spreading out the warp threads by passing through a wraithe during the beaming process. The Scotch name for the same is "porter."

—— (*Linen Manufac.*) "Beer" in Ireland and "porter" in Scotland are terms used in linen manufacture, and signify forty threads of warp. In some cases the fineness of the cloth is expressed by "beers" or "porters"; thus a 40-beer or 40-porter drill means a drill containing forty beers or porters in a set width of cloth—usually 30 in.

Bees (*Art, Archæol.*) The symbol of eloquence.

Beeswax. A secretion of glands in the body of the honey bee, used in the formation of the honeycomb. The wax is used in pharmacy for plasters and ointments. Consists chiefly of myricin (myricyl palmitate, $C_{15}H_{31}COO.C_{30}H_{61}$) and cerotic acid, $C_{27}H_{54}O_2$. Melts at 62° to 65°. Sp. gr. ·962.

Beeswaxing (*Eng., Dec., etc.*) (1) Covering an iron pattern with beeswax to make it more easy to withdraw from the sand of the mould. (2) A method of finishing hard wood furniture, fittings, and floors by rubbing with beeswax thinned with turpentine. It is often called WAX POLISHING. When applied to unwaxed surfaces, the beeswax is cut up in small pieces and digested in turpentine until a paste is produced. Sometimes a little carnauba wax (*q.v.*) is added, to render it firmer. The wax paste is applied by means of a brush. It is easy to apply, and keeps in good condition, while the cost is small. Two coats are given, and each is polished by means of rags or short stiff-bristled brushes. Success depends largely upon the amount of labour given, a light rubbing being useless. Oak and black walnut are the woods on which it is usually employed. On floors such as those of ballrooms the polish must be frequently renewed by sprinkling powdered wax upon the surface and briskly rubbing by means of brushes, which are sometimes attached to the feet of the operator.

Beetroot. *Beta vulgaris* (order, *Chenopodiaceæ*). A variety—the sugar beet—is extensively cultivated in Europe as a source of sugar.

Bel-Etage (*Architect.*) The main story of a building.

Bell (*Architect.*) The body of a Corinthian or Composite capital below the abacus, around which the foliage and volutes are arranged. The same name is also given to the corresponding part of a Gothic capital when its form is similar. *See* COLUMN.

Belladonna (*Botany*). *Atropa belladonna* (order, *Solanaceæ*). The fresh leaves, with or without the branches of the mature plant, and also the dried root, yield the alkaloid atropine, used in ophthalmic practice.

Bell Centre Punch (*Eng.*) A hollow cone, along the axis of which a pointed punch can slide, the point projecting to any suitable distance inside the cone. Used for marking the centre in the end of a round bar or other cylindrical object.

Bell Chuck (*Eng.*) A chuck (*q.v.*) with a cylindrical hollow, usually having set screws projecting into the hollow for holding small work in the lathe.

Bell Crank Lever (*Eng.*) A lever with two arms at right angles, and the fulcrum at the angle or apex.

Belled (*Her.*) Bearing a bell or bells, used of hawks and cows.

Belleville Boiler. *See* BOILERS.

Bell Gable (*Architect.*) A gable at the west end of a church carried up above the roof, and usually containing from one to three bells. It is used in small churches which have no towers.

Bell Metal (*Eng.*) A bronze (*q.v.*); usually copper 16, tin 5; hard and brittle. This alloy gives a strong sound when struck, hence its use for bells.

Bell Metal Ore (*Min.*) A synonym for STANNITE (*q.v.*)

Bells (*Sound*). Constructed of alloys resembling bronze which are found to possess sonorous properties. The modes of vibration and the over-

tones of bells are very complex, as may be readily heard on listening to a large bell at a short distance from it, when many tones can be heard in addition to the principal note.

Bell Traps (*Hygiene*). Under the Drainage by-laws of sanitary authorities, this form of trap, formerly used for receiving wastes from baths, sculleries, etc., is prohibited.

Belly (*Leather Manufac.*) The thin under part of tanned hide: used for slippers, thin straps, and uppers of boots.

—— (*Typog.*) The front or nicked side of a type.

Belt (*Cost.*) A band or cincture used to keep flowing costumes in place, or as a support for a sword, dagger, etc. Generally made of leather, and often richly adorned.

Belt *or* **Strap** (*Eng.*) A strap used for transmitting power by pulleys with a smooth surface: made of leather, cotton, catgut, rubber, etc.

Belt Coupling (*Eng.*) The method of joining the ends of a belt, commonly by lacing or riveting: in catgut belts by a hook and eye screwed on to the ends.

Belt Dressing (*Eng.*) Materials, such as oils, tallow, resin, applied to belts to preserve them.

Belt Fork, Strap Fork (*Eng.*) A device for sliding a belt from one pulley to another alongside it; it has two parallel rods, between which the belt can run freely without contact until the fork is moved along parallel to the shaft, when the belt is displaced by the fork, and is transferred from one pulley to the other without the necessity of stopping its motion.

Belton Stone. *See* BUILDING STONES.

Belt Tension (*Eng.*) The pull in a belt expressed in pounds per square inch of cross section; it varies with the nature of the material, but a good rule is to keep it below 300 lb. per square inch in leather belts. Calculated by dividing the transmitted power in foot pounds by the velocity of the rim of the pulley in feet per minute, and by the cross-section of the belt in square inches.

Belt Transmission (*Motor Cars*). The use of a belt to transmit the power from the engine to the main shaft; now practically confined to motor cycles, though even in this case it is often replaced by a chain similar to an ordinary cycle chain.

Bembridge Series (*Geol.*) A member of the UPPER EOCENE rocks, especially well developed in the Isle of Wight, where they consist of strata which are chiefly estuarine in origin. Their thickness amounts to about 25 ft. They are sometimes classed as OLIGOCENE (*q.v.*)

Ben (*Music*). Well, as *Ben marcato*, well marked.

Bench (*Carp. and Join.*) A very strong and heavy table, fitted with a screw, or vice, and a stop, for joiners to work at. Also applied to the table at which many trades are carried on. *See* BENCH SCREW.

—— (*Mining*). (1) Divisions in seams of coal, consisting of clay, etc. (2) A projection at the outcrop of a seam.

Benched (*Build.*) When a foundation is built on sloping ground it is formed in steps, called benches.

Bench Hook (*Carp.*) An appliance for holding a long piece of work steady on the bench while cutting the shoulders of tenons, planing up, etc.

Bench Marks (*Surveying*). Marks, the position and level of which are known, made in the course of a survey and used for reference. Those made by the Ordnance Survey of Great Britain take the form of a broad arrow, usually chiselled on some permanent stone slab.

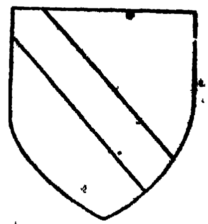
Bench Planes (*Carp.*) Jack, trying, and smoothing planes.

Bench Screw (*Carp.*) A vice at the end of a bench to hold the material to be worked.

Bench Tools *and* **Machines.** Tools and small machines which can be used on the bench (*e.g.* a bench drilling machine), so called in distinction to larger tools and machines which require an independent place in the workshop.

Bench Work (*Carp. and Eng.*) Processes carried out with the smaller tools (and machines) on the bench, as distinguished from processes carried out with the large machines or in the erecting shop.

Bend (*Her.*) An ordinary which crosses the shield from dexter chief to sinister base. If a charge is on it, it occupies one-third of the shield; if uncharged, only one-fifth.



BEND (*Her.*)

—— (*Leather Manufac.*) A butt (*q.v.*) split longitudinally down the middle produces a pair of bends. Bends are bought chiefly by large boot manufacturers for soles.

—— (*Plumb.*) Any curved pipe.

Bending *or* **Flexure.** The amount of curve (or curvature) produced in a beam by the load; its exact measure is given by taking the reciprocal of the "radius of curvature"—*i.e.* the radius of the circle whose curvature most nearly coincides with the curve of the beam. In most cases the curvature of a beam varies, being least at the supports and greatest midway between them.

Bending Cycle Tubes. Tubes are filled with sand, resin, or a soft alloy, and bent over a "former" of the requisite shape. Tubes are bent either hot or cold; if the latter, they must be in a soft (annealed) state first. The process of bending in the cold hardens the tube again, and it is usually left in this condition.

Bending Moment. The bending moment at any point in a beam is the sum of the moments of all the forces acting on the beam on either the right or left side of the cross section through the point—*i.e.* the product of each force into its distance from the point is found, and the sum of all such products on either side of the point gives the total bending moment at the point.

Bending of Strata (*Geol.*) Experiments have been made by Miall upon thin slabs of limestone with a view to finding whether these could be bent by artificial means in such a manner as to retain the flexure and yet not fracture. Pressure applied rapidly caused the slabs to break; but when applied very gradually the resulting flexure proved to be permanent. Amongst highly disturbed rocks some very striking examples of crumpled strata are to be found.

Bendlet (*Her.*) Diminutive of bend; also called a garter; it is one-half of a bend (*q.v.*)

Bendy (*Her.*) Divided into an equal number of bends.

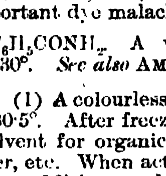
Bengal Lights. Are of various composition—*e.g.* for a white light, shellac, 1 part; barium nitrate, 6 parts; magnesium powder, 2·5 parts: for a red light, 5 parts of strontium nitrate replace the barium nitrate.

Benzalchloride, $C_6H_5CHCl_2$. A liquid boiling at 213° yields benzaldehyde when heated with water, or, better still, milk of lime under pressure. Made by passing chlorine into boiling toluene until the theoretical gain in weight is obtained.

Benzaldehyde, C_6H_5CHO. Oil of bitter almonds. A liquid, smelling like almonds: boils at 179°. It is prepared from bitter almonds, which contain amygdalin (*q.v.*) The amygdalin, acted on by emulsin or hydrochloric acid, yields the oil of bitter almonds. Can be obtained artificially by treating benzylchloride, $C_6H_5CH_2Cl$, with a solution of lead nitrate, or from benzalchloride (*q.v.*) It is easily oxidised to benzoic acid, C_6H_5COOH. Much used in flavouring sweets, etc., and in the manufacture of the important dye malachite green.

Benzamide, $C_6H_5CONH_2$. A white crystalline solid melting at 130°. *See also* AMIDES.

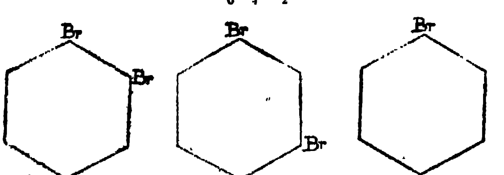
Benzene, C_6H_6. (1) A colourless peculiar-smelling liquid boiling at 80·5°. After freezing, it melts at 6°. It is a valuable solvent for organic substances, such as fats, indiarubber, etc. When acted on by chlorine in sunlight it forms addition products—*e.g.* benzene hexachloride, $C_6H_6Cl_6$. Chlorine in presence of iodine (halogen carrier) gives substitution products—*e.g.* monochlorbenzene. Bromine behaves in the same way. Nitric acid yields according to conditions of action nitrobenzene (*q.v.*) or metadinitrobenzene (*q.v.*) Boiled with sulphuric acid, it gives benzene sulphonic acid; when one monovalent atom such as bromine or one monovalent group such as the nitro group (NO_2) replaces one of the six hydrogen atoms in benzene, only one compound is obtained, no matter which hydrogen atom is replaced. When two such atoms or groups replace two hydrogen atoms, three and only three compounds can be obtained; when three such atoms or groups replace three hydrogen atoms, three compounds are again obtained. The only formula for benzene which accounts for these facts is the following:



BENZENE.

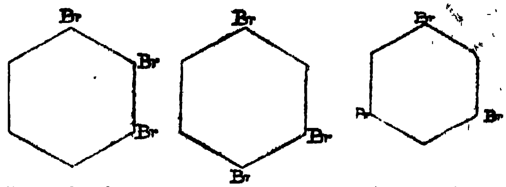
in which the carbon atoms are joined in a ring and one H atom is attached to each. (The ring is represented by the regular hexagon.) So we have

$C_6H_4Br_2$



Ortho-dibrombenzene or 1:2-dibrombenzene. Meta dibrombenzene or 1:3-dibrombenzene. Para-dibrombenzene or 1:4-dibrombenzene.

$C_6H_3Br_3$



Vicinal tribrombenzene or 1:2:3 tribrombenzene. Unsymmetrical tribrombenzene or 1:3:4 tribrombenzene. Symmetrical tribrombenzene or 1:3:5 tribrombenzene.

The carbon atoms are numbered as shown in the figure; also the C and H atoms are often omitted for convenience. Each C atom is represented as trivalent; the exact mode of disposal of the fourth combining unit is unknown. Benzene is obtained by heating benzoic acid with soda lime. On the large scale it is obtained from coal tar (*see* COAL GAS MANUFAC.) The part which distils up to 170° is redistilled, and the part up to 110° shaken with sulphuric acid, then caustic soda, and again distilled. The part that distils at 80° to 82° is fairly pure benzene. Benzene is also obtained synthetically by heating acetylene gas.

Benzene Sulphonic Acid, $C_6H_5SO_2OH$. When benzene is boiled with sulphuric acid for some hours, combination occurs, and this substance is formed. Colourless plates melting at 50° readily soluble in water and alcohol. Fused with caustic soda, it gives phenol, used in the manufacture of ether.

Benzidine, $H_2N \,.\, C_6H_4 \,.\, C_6H_4 \,.\, NH_2$. *Paradiamidodiphenyl.* White plates melting at 122°. Formed by reduction of azobenzene with tin and hydrochloric acid:

$$C_6H_5N = N \,.\, C_6H_5 \rightarrow \underset{\text{H}}{C_6H_5NH} \,.\, \underset{\text{Hydrazobenzene.}}{NH \;\; C_6H_5} \rightarrow$$

$$H_2NC_6H_4 \,.\, C_6H_4NH_2.$$

Parent substance of a number of dyes capable of dyeing cotton without a mordant—*e.g.* Congo red. *See also* DYES AND DYEING.

Benzine. A popular term, not used in exact nomenclature. Sometimes applied to commercial benzene, sometimes to petroleum, which is quite a different substance chemically.

Benzoic Acid, C_6H_5COOH. A shining white crystalline solid of characteristic smell; melts at 120°; soluble, 1 in 400 parts water at 15°; readily in hot water, also in alcohol and ether. It is a powerful antiseptic. When taken internally, it appears in the urine as hippuric acid (*q.v.*) Obtained by sublimation from gum benzoin, which contains 12 to 20 per cent. of the acid; also as a byeproduct in the manufacture of benzaldehyde. When heated with lime (CaO), it gives benzene (C_6H_6). With bromine, nitric or sulphuric acid it forms metasubstitution products.

Benzoin (*Botany*). *Styrax benzoin* (order, *Styracaceæ*). A fragrant resin obtained by incision of the bark. It is used in medicine, in perfumery, and in making incense.

Benzol. Another name for Benzene.

Benzonitrile. *See* NITRILES.

Benzophenone, $C_6H_5COC_6H_5$ (*Diphenylketone*). Crystalline solid existing in two forms—an unstable

form melting at 26°, and formed by boiling the stable form, which melts at 46°: the former reverts to the latter on standing. Pleasant smell. Obtained from benzene, and either benzoylchloride or carbonylchloride, in presence of aluminium chloride; also by distilling calcium benzoate. Distilled with zinc dust yields diphenylmethane. *See also* KETONES.

Benzopurpurines. May be regarded as benzidine derivatives; they are dyes which dye unmordanted cotton red. Benzopurpurine B is

$$\begin{array}{l} C_6H_3\left\langle\begin{array}{l}N = N - C_{10}H_5\left\langle\begin{array}{l}NH_2\\SO_3Na\end{array}\right.\\CH_3\end{array}\right.\\ \quad | \\ C_6H_3\left\langle\begin{array}{l}CH_3\\N = N - C_{10}H_5\left\langle\begin{array}{l}SO_3Na\\NH_2\end{array}\right.\end{array}\right.\end{array}$$

This is the salt known as Congo red. *See also* DYES AND DYEING.

Benzoquinone. *See* QUINONE.

Benzoyl. The name given to the group C_6H_5CO-. It does not exist uncombined. BENZOYLCHLORIDE, $C_6H_4 . CO . Cl$, is an important reagent in organic chemistry; it is a colourless fuming liquid boiling at 200°. Obtained by action of phosphorus pentachloride on benzoic acid. Decomposed by water into hydrochloric and benzoic acids. *See also* BAUMANN-SCHOTTEN REACTION.

Berberine, $C_{20}H_{17}NO_4$. An alkaloid found in a number of plants—*e.g. Berberis vulgaris*, yellow-brown needles melting at 145°. Optically inactive; soluble in water and in alcohol. Forms gold-coloured salts. Alkalis colour its solution red, and chlorine water colours its hydrochloride blood red. It is not official. It is probably a quaternary ammonium base (*q.v.*) Among its oxidation products may be mentioned $\alpha\,\beta'\,\gamma$, pyridine tricarboxylic acid, hemipixic acid (1 : 2 methoxybenzene, 3 : 4 dicarboxylic acid), and hydrastic acid, the latter showing that berberine is related to hydrastine.

Bergamot (*Botany*). *Citrus aurantium* (var., *Bergamia*; order, *Rutaceæ*). A fragrant essence extracted from the rind of the fruit of a variety of the orange. *See* CITRUS.

Berkefeld Filter (*Hygiene*). This is a valuable form of domestic filter; it consists of a cylinder of diatomaceous earth called Kieselguhr, which is enclosed in an outer case. The water enters at the top under pressure, and is forced inwards through the earth. It frees the water from organisms.

Berlin Blue. Another name for Prussian blue (*q.v.*)

Berthelot's Calorimeter (*Heat*). An apparatus for determining the latent heat of evaporation of liquids by condensing the vapour in a helical tube immersed in a vessel of water whose rise of temperature can be noted.

Beryl (*Min.*) A silicate of aluminium and beryllium, $3BeSiO_3 . Al_2Si_3O_9$: silica = 66·8, aluminium = 19·1, berylla = 14·1 per cent. Hexagonal. Colour, emerald green to dirty brown or grey. One opaque crystal from Massachusetts was said to weigh 2½ tons. The bright green variety is EMERALD (*q.v.*), the blue green is AQUAMARINE (*q.v.*); both valuable as gems. Brazil, Siberia, and Saxony are important localities. *See also* PRECIOUS STONES.

Beryllium, Be. Atomic weight, 9. Called also GLUCINUM, from the fact that some of its salts—*e.g.* the sulphate—are sweet tasted. It is a white metal, obtained by heating the chloride $BeCl_2$ with sodium. It belongs to the same chemical family as magnesium. It is found in the BERYL (hence its name) and in emerald.

Bessemer Converter (*Met.*) The pear-shaped vessel used in converting cast iron to steel in the Bessemer process (*q.v.*)

Bessemer Pig (*Met.*) Cast (or pig) iron specially suited to the Bessemer process. For the acid process an ore with a relatively high amount of silica (SiO_2), not less than 2 per cent., and a low percentage of sulphur and phosphorus, was preferred; for the basic process the reverse is the case, the phosphorus giving a valuable slag.

Bessemer Process (*Met.*) The conversion of cast iron to steel by oxidising the carbon by means of a current of air blown through the iron while molten; the air oxidises the carbon to carbonic oxide (CO_2) and carbon monoxide (CO), and at the same time maintains the iron at a suitably high temperature by this oxidation, until practically the whole of the carbon is removed. *See also* IRON *and* STEEL.

Best *and* **Best Best,** *or* **B.** *and* **B.B.** Grades of cast iron. *See* IRON.

Bestiarium (*Archæol.*) A name given to early books on natural history. They were often in verse, and moralised on the peculiarities of animals.

Betaine, $\begin{array}{l}CH_2 - N(CH_3)_3\\ \ | \qquad\quad |\\ CO \ - \ O\end{array}$ (*Oxyneurine, Lycine, Trimethylglycocoll*). Hygroscopic crystals; forms well crystallised salts. Occurs in the sugar beet, in cotton seed, and in wheat sprouts. Has been found with ptomaines in some poisonous edible mussels. Obtained by careful oxidation of choline (*q.v.*); also when trimethylamine is heated with monochloracetic acid. It is not poisonous.

Beton (*Build.*) *See* CONCRETE.

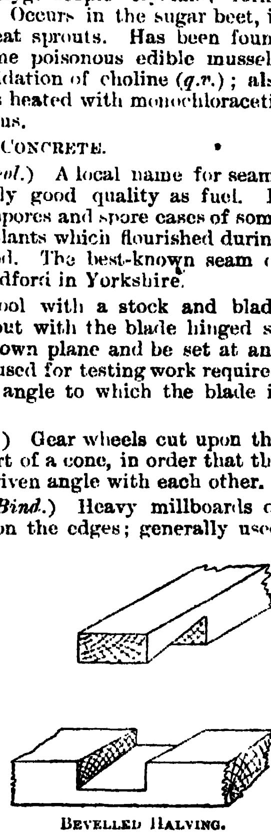
Better Bed Coal (*Geol.*) A local name for seams of coal of exceptionally good quality as fuel. It consists largely of the spores and spore cases of some of the lycopodiaceous plants which flourished during the Carboniferous Period. The best-known seam of the name occurs at Bradford in Yorkshire.

Bevel (*Tools*). A tool with a stock and blade resembling a square, but with the blade hinged so it can be moved in its own plane and be set at any angle with the stock; used for testing work required to be cut to any given angle to which the blade is previously adjusted.

Bevel Gearing (*Eng.*) Gear wheels cut upon the surface of a cone or part of a cone, in order that the shafts may run at any given angle with each other.

Bevelled Boards (*Bind.*) Heavy millboards of good quality, bevelled on the edges; generally used for antique work.

Bevelled Halving (*Carp.*) HALVING (*q.v.*) in which the internal cut surfaces which are in contact are inclined at a small angle to the plane of the two pieces of timber; it is only used when there is a heavy pressure on the wood which keeps the joint in place.



BEVELLED HALVING.

Bevelling (*Carp, etc.*) To form an acute or obtuse angled surface.

Bezant (*Archæol.*) A gold coin of Byzantium, an ancient city of Thrace, situate on the Bosphorus. When the seat of the Roman government was fixed there by Constantine the Great in 330 A.D., the name was changed to Constantinople. Bezants were current in England from the tenth century to the reign of Edward III.

Bezants (*Her.*) Flat gold roundles or circles, without impress. Originally gold coins struck at Byzantium.

Bezants Tourteaux (*Her.*) Roundles in which the dexter side is half a bezant (*or*) and the sinister half a tourteau (*gules*).

Bezanty **Bezantée** (*Her.*) Charged with bezants.

Bezel. (1) The edge and oblique faces of a cut gem. (2) The grooved ring for holding the glass of a watch or clock. (3) The sloping edge of a cutting tool.

Biacca (*Paint.*) White lead.

Biadetto (*Paint.*) A blue paint made from copper.

Bianco Secco (*Paint.*) A wash or paint made from lime, used in fresco work.

Biaxial Crystal (*Physics*). One with two OPTICAL AXES (*q.v.*)

Bibcock (*Eng.*) A tap or cock of the ordinary shape in which the nozzle is bent downward.

Bibelots (*Art*). Objects of art, or curiosities, used for decorative purposes.

Bicarbonates. Compounds formed by replacement of half the replaceable hydrogen of carbonic acid by metals. Carbonic acid has the formula H_2CO_3; sodium bicarbonate is $NaHCO_3$; potassium bicarbonate is $KHCO_3$; and calcium bicarbonate is $Ca(HCO_3)_2$.

Bice (*Paint.*) A blue paint, inferior to ultramarine.

Bichromates (*properly called* **Dichromates**). Salts of the unknown acid $H_2Cr_2O_7$; *e.g.* $K_2Cr_2O_7$ is potassium dichromate, often called bichromate of potash.

Bickern. A BEAK IRON (*q.v.*)

Biclinium (*Archæol.*) A couch or settee for two persons.

Bicorporate (*Her.*) Having two bodies joined to one head.

Bicycle. A bicycle may be defined as a vehicle propelled by foot power by the rider, and having two wheels in line with each other. *See also* CYCLES.

Biennial (*Botany*). A herbaceous plant which persists for two seasons. In the second year the plant flowers and fruits.

Bifilar Suspension (*Phys., Mechanics*). Two similar fibres of equal length, and usually parallel, are often used to suspend an object, such as an electrometer needle. At rest, the two fibres lie wholly in the same plane; if the suspended object be turned, it is slightly raised at the same time, and gravity tends to restore it to its original position. Thus a continual directive force is obtained which is independent of any torsion in the fibres themselves, or of magnetic or other external forces.

Bifrons (*Sculp.*) Two faces put back to back so as to form one head—*e.g.* Janus is often so represented.

Biga (*Archæol.*) A Roman chariot drawn by a pair of horses.

Bight. A loop in a chain or rope; also a general term for a bend.

Bile (*Zoology*). A secretion of the liver stored up in the gall bladder. It is passed out into the duodenum (*q.v.*) by means of the bile duct. Bile is alkaline, counteracting the acidity of the chyme. It also acts upon fats to form an emulsion.

Bilge Water (*Eng.*) The water which accumulates in the bottom of a ship's hold; it is removed by bilge pumps, worked by hand or steam, or occasionally in old ships by a small windmill on deck.

Bill (*Arms*) A cutting weapon with a curved point like a beak of a bird, used in warfare in the fourteenth and fifteenth centuries.

BILL, 15TH CENTURY.

—— (*Typog.*) A list or scale of the quantity of each letter required for a fount of type.

Billeté (*Her.*) Strewn with billets.

Billet Moulding (*Architect.*) An enriched moulding used in Norman strings and archivolts. It consists of a series of small pieces or billets, either circular or square in cross section, placed in a hollow moulding, the spaces between the billets being usually the same length as the billets.

Billets (*Her.*) A charge like a small oblong, sometimes shown voided.

Bill Head *or* **Bill Hook.** A cutting instrument curved at the end and broad in the blade.

Bind *or* **Tie** (*Music*). A curved line placed over or under two notes of the same pitch to show that the second is not to be re-struck, but the sound of the first note is to be sustained for the time of the two. Sir W. S. Bennett introduced the sign ⎴ instead.

Binder *or* **Binding Joist** (*Carp.*) The beam supporting the common or bridging joists (*q.v.*)

Binders for Slides (*Photo.*) The strips of black or coloured paper used to fasten round the edge of lantern slides to hold the plate and its cover glass together.

Binding Straps (*Eng., etc.*) The metal holders of the tool in planing and shaping machines.

Binding Wire. Fine wire (iron, brass, or copper) used for holding small joints during brazing, or sometimes permanently.

Bioscope. *See under* CINEMATOGRAPH.

Bioses (*Chem.*) A name given to those sugars which contain twelve atoms of carbon and are resolved on hydrolysis into two sugars, each of which contains six carbon atoms; *e.g.* cane sugar, maltose, and lactose are bioses.

Biotite (*Min.*) One of the mica group. A silicate of magnesium, potassium, iron, and aluminium, the exact composition of which varies considerably. It is a common constituent of eruptive and metamorphic rocks, and is widely distributed. It is monosymmetric, and it usually occurs as pseudo-hexagonal plates with a perfect basal cleavage; the laminæ are transparent and elastic.

Bipennis (*Arms*). A double-edged axe

Birch. *See* WOODS.

Birdbolt (*Her.*) A blunt arrow.

Birdlime. Not a definite chemical substance; it contains about 6 per cent. of caoutchouc, esters of palmitic acid, and other substances of unknown constitution. It is prepared from the inner bark of the holly.

Bird of Paradise (*Zoology*). Family, *Paradiseidæ*; order, *Passeres.* A Polynesian family of birds, of nearly fifty species, much sought after for the sake of their beautiful plumage.

Bird's Beak (*Architect.*) A moulding used in Greek architecture. It consists of an ovolo or an ogee with a hollow moulding under, and with or without a fillet between. It is frequently used in the capital of the Greek Doric anta.

Bird's Eye (*Plumb.*) A hole accidentally made in a pipe by a clumsy workman.

Bird's Eye Maple (*Dec.*) Grainers in imitating this wood prepare a ground of white lead tinted either with a very little vermilion or with Oxford ochre. The graining colour is usually burnt umber ground in water, to which is added a little raw sienna. *See also* WOODS.

Bird's Eye View. A view of a landscape such as would be seen by a bird flying.

Bird's Mouth (*Carp.*) A triangular notch. Rafters are birdsmouthed on to the wall plate.

Biremis (*Archæol.*) An ancient vessel with a double bank of oars on each side.

Biretta, Beretta (*Cost.*) A square-shaped cap worn by persons in orders (R.C.Ch.) The biretta of the priest is black, that of a bishop purple, and that of a cardinal red.

Birkhill Shales *or* **Graptolitic Mudstones** (*Geol.*) A section of the Silurian rocks, of marine origin, well developed in the Lake District, and near Moffat, as well as at other places in the south of Scotland. It consists of a small thickness of black mudstones, which seems to have been formed in deep water, and near the outer verge of the area of terrigenous deposits. It contains an extensive suite of graptolites, many species of which occur only on a definite platform within these rocks, and thus form palæontological zones of much value in stratigraphical geology.

Birth Rate (*Hygiene*). The birth rate of a town is calculated in the following manner: Supposing a town has a population of 170,000, and the number of births during the year is 4,850, then the annual birth rate is

$$\frac{4{,}850 \times 1{,}000}{170{,}000} = 28{\cdot}5.$$

The death and marriage rates are calculated in the same way.

Bis (*Music.*) Twice: shows that the portion so marked is to be performed twice.

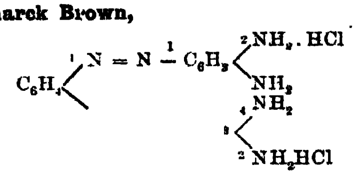
Biscuit (*Pot.*) *See* BISQUE.

Biscuit Oven (*Pot.*) *See* BISQUE OVEN.

Bisellium (*Archæol.*) Literally, a seat or chair for two; allotted to distinguished persons as an honour on public occasions among the Romans.

Bishops' Length (*Paint.*) Canvas, 58 by 94 in.

Bismarck Brown,



A dye obtained from metaphenylene diamine by the diazo reaction (*q.v.*) Its formation is used as a test for the presence of nitrites in water. *See also* DYES AND DYEING.

Bismuth, Bi (*Chem.*) Atomic weight, 208. A brittle crystalline metal, greyish-white colour, with tinge of pink. To obtain it the ore is roasted and then melted with charcoal, iron, and slag obtained in smalt making. It is readily oxidised to the oxide Bi_2O_3; scarcely acted on by hydrochloric acid, but readily by nitric acid forming the nitrate. Hot strong sulphuric acid forms the sulphate $Bi_2(SO_4)_3$. Bismuth is used in making "fusible metals." This element occurs native in foliated or granular masses and also in branching forms running through the matrix. It crystallises in rhombohedral forms, much resembling a cube. Often found in association with ores of silver, cobalt, zinc, and lead. The native metal is the most important source of bismuthe. Obtained from Botallack in Cornwall, Caldbeck Fells in Cumberland, Saxony, Bohemia, Norway, etc.

Bismuth Compounds. BISMUTH OXIDE, Bi_2O_3, a brownish-yellow compound obtained by heating the nitrate; insoluble in water, soluble in acids. BISMUTH CHLORIDE, $BiCl_3$, forms white deliquescent crystals, and is obtained by dissolving the oxide in hydrochloric acid or the metal in *aqua regia*; its solution gives, with much water, a white precipitate of BISMUTH OXYCHLORIDE, BiOCl. BISMUTH NITRATE, $Bi(NO_3)_3$, a white deliquescent crystalline solid formed by dissolving the metal, oxide, or carbonate in nitric acid. With water its solution forms the important BISMUTH OXYNITRATE, $BiONO_3$, a basic nitrate; insoluble in water as such, but decomposed by it on prolonged action. Much used in medicine as an astringent and antiseptic; also used as a cosmetic and in painting on porcelain.

Bismuthine (*Min.*) Bismuth trisulphide, Bi_2S_3; it usually occurs in acicular crystals of the rhombic system. Sometimes massive. Colour, lead grey. From Cornwall, Cumberland, Saxony, etc.

Bismuth Ochre (*Min.*) Native bismuth trioxide, Bi_2O_3; its form is rhombic. It occurs as a greenish-yellow incrustation on other bismuth ores, but is not common.

Bisque (*Pot.*) The term given to pottery or porcelain after firing in the bisque oven and before being glazed.

Bisque Oven, Biscuit Oven (*Pot.*) Is that in which the clay articles are placed, and the heat of which renders them more or less vitrified.

Bistre (*Paint.*) A brown pigment prepared from soot.

Bisulphates (*Chem.*) Salts of sulphuric acid (H_2SO_4) in which half the hydrogen of the acid is unreplaced by metals; *eg.* $KHSO_4$ is potassium bisulphate.

Bisulphites (*Chem.*) Salts of sulphurous acid (H_2SO_3) in which half of the hydrogen of the acid is unreplaced by metals; *e.g.* $NaHSO_3$ is sodium bisulphite.

Bit (*Carp.*, *Eng.*) Name applied to several tools or parts of tools—*e.g.* the copper tool used in soldering (*see also* SOLDERING IRON), and the cutting tool used with a brace or drill. *See* TWIST BIT, CENTRE BIT, *etc.*

Bite (*Typog.*) A blank left in a printed page owing to the frisket accidentally covering a portion of the forme.

Biting In (*Engrav.*) The action of the acid on metal in etching. *See* ENGRAVING AND ETCHING.

Bittern (*Chem.*) The mother liquor remaining after common salt has been separated by crystallisation from sea water. It was in this liquor that Balard discovered bromine in 1826.

Bitter Spar (*Min.*) A ferruginous variety of DOLOMITE (*q.v.*)

Bitumen (*Paint.*) A pigment made from asphalt, of a colour resembling sepia. Being susceptible to the weather, it should be used very sparingly, or perhaps it would be better not at all. Cf. many of the pictures of Sir Joshua Reynolds.

Bitumens (*Min.*) A series of carbon compounds of the olefiant and paraffin groups. They usually occur as mixtures. Most are semi-solid or liquid, and many have aromatic odours. The principal members are: Hachettite (carbon = 85·5, hydrogen = 14·5 per cent.); Ozocerite (carbon = 84·5, hydrogen = 13·7 per cent.); Amber (carbon = 79·0, hydrogen = 10·5, oxygen = 10·5 per cent.); Petroleum (a mixture of the series C_nH_{2n+2}), Asphalt, Naphtha, etc.

Bituminous Coal. Coal containing a large amount of tarry matter or bitumen. *See also* COAL.

Bituminous Paint (*Eng.*) A paint or varnish composed of tar mixed with resin and tallow; used for ironwork under water.

Biuret (*Chem.*) A compound formed by carefully heating urea at 150° to 160°. Needles, soluble in water and alcohol; melts at 190°.

$$\underset{\text{Urea.}}{2CO\begin{matrix}\diagup NH_2\\ \diagdown NH_2\end{matrix}} = \underset{\text{Biuret.}}{\begin{matrix}CO\diagup NH_2\\ \quad\ \ \diagdown NH\\ CO\diagup \\ \quad\ \ \diagdown NH_2\end{matrix}} + NH_3$$

Caustic soda and copper sulphate solutions added to its solution in water give a violet red colouration. On heating, biuret yields ammonia and cyanuric acid (*q.v.*)

Biuret Reaction. When caustic soda and copper sulphate solutions are added to an aqueous solution of an albumin a violet red colour is produced, while albumoses and peptones give a pure red colour. The coloured compound has the formula:

$$NH\left\langle\begin{array}{c}CO - NH_2 - Cu - H_2N - CO\\ \quad\ \ | \qquad\qquad\quad\ \ |\\ \quad OH \qquad\qquad\ HO\\ \quad OH \qquad\qquad\ HO\\ \quad\ \ | \qquad\qquad\quad\ \ |\\ CO - NH_2 - KK - H_2N - CO\end{array}\right\rangle NH.$$

The biuret reaction is given by all substances which contain $2(-CONH_2)$ or $2(-CSNH_2)$: groups united either (1) to each other, (2) to the same carbon atom, (3) to the same nitrogen atoms. It will detect one part of a peptone in 100,000 of water; less sensitive for other substances.

Black (*Eng.*) Applied to work left rough just as it came from the forge or foundry, as well as to work which has been treated with a varnish, paint, or other coating.

Black (*Paint.*) The so-called colour is due to the circumstance that the substances composing it absorb all the rays of light and reflect none. Black pigments are either made by incompletely burning various organic substances or are found in a mineral state. Among the former are carbon black, bone black, lamp black, ivory black, Spanish black, and vegetable black; among the latter, graphite, Frankfort black, etc. *See also* BRUNSWICK BLACK, DROP BLACK, *and* GAS BLACK.

——, **Aniline.** *See* DYES AND DYEING.

Black Ash. *See* ALKALI.

Black Band Ore (*Min.*, *Met.*) Clay iron ore (*q.v.*) mixed with bituminous matter. Occurs chiefly in shales of Carboniferous age in various parts of Britain, in Germany, and some other places.

Black Chalk. A mineral substance used for making crayons.

Black Copper (*Met.*) The product of one of the stages of smelting copper.

Black Damp (*Mining*). Carbonic acid gas.

Black Diamond *or* **Carbonado** (*Min.*) Synonyms for BORT (*q.v.*)

Blackdown Beds (*Geol.*) A subdivision of the CRETACEOUS ROCKS which has yielded an abundant marine fauna. Its precise geological position has formed the subject of much discussion.

Black Flux. A mixture of potassium carbonate and charcoal obtained by heating cream of tartar out of contact with air. For some purposes this mixture contains too much carbon; in this case the cream of tartar is heated with more or less nitre. *See* FLUX *and* REDUCING MIXTURES.

Blacking *or* **Blackening** (*Moulding*). Carbonaceous dust (graphite, ground charcoal, etc.), which is dusted over the surface of a mould to prevent sudden contact of the fluid metal and the sand of which the mould is formed.

Blacking Mill (*Moulding*). The grinding machine for preparing the fine powder used for blacking a mould.

Black Jack (*Archæol.*) A capacious can, formerly made of waxed leather, but now made of metal.

—— (*Min.*) A synonym for ZINC BLENDE (*q.v.*), used by miners.

Black Japan (*Dec.*) A black quick drying varnish much used by carriage painters, but useful also to house painters in preparing rich dark colours for glazing and scumbling (*q.v.*) The absence of a greenish or a reddish cast is the chief characteristic of good quality.

Blacklead (*Eng.*, *etc.*) Graphite (or plumbago), one of the natural forms in which carbon occurs. Used as a lubricant where oil is undesirable—*e.g.* on cycle chains, on wooden surfaces where friction occurs, and on the surfaces of patterns to facilitate withdrawal from the mould; also used in the foundry as BLACKING (*q.v.*) *See also* PLUMBAGO.

Black Letter (*Typog.*) A name applied to the form of type used by the early printers, which was subsequently displaced by "Roman" type. Also called "Gothic" or "Old English." The following are black letter type of the sixteenth century: 𝔄 𝔅 ℭ.

Black Oils. Mineral oils which have not been chemically purified. Used for lubrication if sufficiently viscous. *See* PARAFFIN *and* FULLER'S GREASE.

Black Sand (*Moulding*). Old foundry sand, forming the floor of the foundry, and used for the main part of a mould, but not in immediate contact with the pattern.

Black Smoke (*Eng., etc.*) The result of incomplete combustion caused by faulty grates or careless stoking. The discharge of black smoke is forbidden by law, and, moreover, represents an enormous loss of fuel, since the furnace gases are carrying off great quantities of carbon in a very finely divided form.

Black Tellurium (*Min.*) A synonym for NAGYAGITE (*q.v.*)

Blackwood. *See* WOODS.

Blade. The cutting portion of various tools, or the thin, flat part of a square, bevel, etc.

Bladed (*Her.*) When the stalk of corn is of a different tincture from the ear.

Blanc Fixe (*Dec., etc.*) An artificial sulphate of barium, very white and fine and somewhat heavy. Principally used in papermaking and in the manufacture of wallpaper colours. It also enters largely into the composition of lithopone (*q.v.*), Orr's white, etc.

Blank (*Coins*). The disk stamped out of a sheet of metal ready for striking.

—— (*Eng.*) A piece of metal roughly cut, cast, or forged to a particular shape ready for accurate working up by hand or machine.

Blank End (*Eng., etc.*) The closed end of a pipe or channel.

Blanket (*Woollen Manufac.*) A thick, heavy fabric, usually plain woven and covered with fibres on both sides. WOOLLEN BLANKETS are made of wool; UNION BLANKETS of a cotton warp and wool weft. COTTON BLANKETS are made entirely of cotton with a soft spun weft.

—— (*Engrav.*) A piece of woollen material wrapped round the roller of a press to equalise the pressure.

Blank Hole (*Eng.*) A misplaced rivet or bolt hole which comes opposite to solid material instead of a corresponding hole.

Blank Wall (*Build.*) A wall without an opening in it.

Blank Window (*Build.*) A window opening filled up with brickwork in the form of a panel.

Blast (*Met.*) Air forced into a furnace by a fan or blower. Used in nearly all metallurgical operations, and in steam boilers when required to work at their maximum capacity. *See* FORCED DRAUGHT.

Blasted (*Her.*) A branch with all its leaves torn off; also termed "starved."

Blast Furnace (*Met.*) A vertical furnace with a constriction or narrowing at the top and bottom; made of iron or brick, lined with some very refractory firebrick or other material. For producing pig iron from the ore, which is shot in from the top along with fuel and some flux, and kept at an intense heat by a hot or (less frequently) cold blast. Once lit, the furnace may run for several years before being "blown out" or stopped. The fluid iron is drawn off at intervals from the lower part, the slag (which collects above the iron) being drawn off continuously through a special opening. *See also* FURNACES.

Blasting Gelatine. An explosive mixture of nitroglycerine and nitrocellulose, less highly nitrated than gun cotton.

Blast Main (*Eng.*) The large pipe carrying the air from the fan or blower to the furnace.

Blast Pipe (*Met.*) The pipe discharging the exhaust steam of a locomotive into the chimney, thus producing a forced draught through the fire.

Blazed Pig *or* **Glazed Pig** (*Met.*) Inferior pig iron containing a high percentage of silica. It is often produced soon after a furnace is started.

Blazing Off (*Eng.*) Tempering steel by coating it, after hardening, with grease or oil, and heating till the vapour from the oil "flashes" or lights.

Blazon (*Her.*) (1) A shield or coat of arms; the charges or devices are called "blazons." (2) A description of armorial bearings in proper heraldic terms.

Blazonry (*Her.*) The art of delineating or describing coats of arms in proper heraldic terms.

Bleached Cotton Cloths (*Cotton Weaving*). A variety of makes may be included under this heading. All of them are woven and purely sized in the grey state, and bleached afterwards. The following are a few: Longcloths, cambrics, jacconettes, lawns, nainsooks, toilets, lenos, etc.

Bleaching. The removal of colouring matter from a fabric by a process of oxidation or reduction. OXIDATION is effected by soaking the fabric in a solution of bleaching powder (*q.v.*), then in a dilute acid, such as sulphuric acid; in this way hypochlorous acid (*q.v.*) is liberated, and this oxidises the colouring matter to a colourless compound. REDUCTION is effected by submitting the fabric to the action of sulphurous acid (*q.v.*); this is often done by suspending the fabric in a closed room, on the floor of which sulphur is burnt. In this case hydrogen is added to the colouring matter, and a colourless product is formed. Fabrics bleached in this way are liable to regain their colour on exposure to air and light. Cotton and linen are bleached by the first method, and wool, silk, and straw by the second. In all cases the fabric should be chemically cleaned before being subjected to the bleaching process. Hydrogen peroxide, obtained by the action of hydrochloric acid on sodium peroxide (*q.v.*), is now sometimes used as a bleaching agent: it bleaches by oxidation.

—— (*Paper Manufac.*) The process of making disintegrated rags or other pulp perfectly white by means of chloride of lime.

Bleaching Powder. A white powder of the composition $Ca\left\langle\begin{matrix}Cl\\OCl\end{matrix}\right.$. It is prepared by passing chlorine over good slaked lime ($Ca(OH)_2$). The operation is carried out in stone chambers, and lasts some days. Heat is evolved during the absorption of the chlorine. Bleaching powder changes on exposure to air and moisture; it contains unchanged slaked lime. When treated with water, the solution contains calcium chloride and hypochlorite: $2Ca.OCl.Cl = CaCl_2 + Ca(OCl)_2$. Acids decompose it, giving chlorine or hypochlorous acid; *e.g.* with hydrochloric acid we may suppose hypochlorous acid is liberated first, and immediately decomposed by hydrochloric acid, giving chlorine:

$$Ca(OCl)_2 + 2HCl = CaCl_2 + 2HOCl$$
$$2HOCl + 2HCl = 2H_2O + 2Cl_2.$$

Its solution, warmed with a solution of a cobalt salt, gives a steady current of oxygen.

Bleak (*Zool.*) *Alburnus lucidus* (family, *Cyprinidæ*). A small fish of the carp tribe found in Europe and Western Asia. Its scales are used in making artificial pearls.

Bled (*Bind.*) When the edge of a book has been cut down to such an extent that the print is affected, it is said to have been "bled."

Bleed (*Plumb.*) To bleed a pipe is to make a small hole to run off the water so that the pipe can be repaired.

Blend (*Paint.*) To gradually pass from one colour to another without abrupt transition.

—— (*Woollen Manufac.*) A mixture of fibres ready for carding.

Blende (*Min.*) Zinc sulphide, ZnS (zinc = 66, sulphur = 34 per cent.); usually a little cadmium is present. Also called SPHALERITE, and by the miners Black Jack. It occurs in complex forms of the cubic system. At one time it was rejected as a useless gangue metal, but now it is a valuable source of zinc and cadmium. Colour usually black. Often associated with lead, copper, and silver ores, and barytes. From Alston Moor, Saxony, Spain, Sweden, Belgium, etc.

Blending (*Woollen Manufac.*) The operation of mixing wool, cotton, mungo, etc. Blending has three distinct applications: (1) To the mixture of two or more qualities of material; (2) to the mixture of two or more colours of material; (3) to the mixture of several qualities and colours of material.

Blind Drift (*Mining*). A passage not leading to any other working; a "cul de sac."

Blind Lode *or* **Vein** (*Mining*). A vein with no outcrop (*q.v.*)

Blind P. (*Typog.*) A paragraph mark, ¶, so named because the loop of the *P* is closed.

Blind Tooling (*Bind.*) Ornamental impressions on the cover of a book produced by heated blocks or tools, not finished with gilt. Called also ANTIQUE.

Blister (*Paint.*) A swelling of the paint on the surface of a picture.

Blister Copper (*Met.*) "Fine metal" (*q.v.*) which has been roasted to expel sulphur and then melted and run into moulds. The gases escaping from the molten copper produce a blistered appearance. *See also* COPPER.

Blistering (*Dec.*) A frequent and serious fault of painted work. Arises from a variety of causes, the most common of which are (1) painting upon a damp surface, (2) imperfect adhesion between coats of paint, (3) improper treatment of knots, (4) the use of too much oil. Painted work in some positions is very liable to become blistered, especially where it receives the full force of the sun. Executing the work in sharp, flat colour (*q.v.*), and afterwards varnishing, generally prevents blistering. A good washable water paint may also be used with success, with a varnished finish. It is important that in every case ample time be given for each coat to dry.

Blisters (*Photo.*) Occur in a film through careless handling or uneven drying in manufacture. They may sometimes be checked by flooding the plate with methylated spirit.

Blister Steel (*Met.*) Steel produced by the cementation process (*q.v.*) The appearance is due to the escape of carbonic oxide gas. *See also* IRON *and* STEEL.

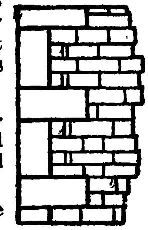
Block (*Eng., etc.*) The wood or metal frame or case carrying the pulleys in lifting tackle.

—— (*Sculp.*) A solid piece of stone or wood unworked.

—— (*Engrav.*) A piece of hard wood on which an engraving is cut.

—— (*Typog.*) A term embracing woodcuts, zincos, electros, etc.

Block and Start (*Build.*) Stones next to an opening, when alternately long and short, form block and start work, as in the figure. *See* QUOINS *and* LONG AND SHORT WORK.



BLOCK AND START.

Block Chain (*Cycles*). *See* CYCLES.

Block Coal. Coal with well marked horizontal and vertical divisional planes.

Block in Course (*Build.*) Stone walling, used chiefly for embankments, etc.; similar to ashlar work (*q.v.*)

Blocking *or* **Backing** (*Carp.*) Pieces of wood let in or fixed to the walls of buildings. To these the joiner's work is secured.

Blocking Course (*Architect.*) A plain course of stone in a classical building placed at the top of a wall immediately above the cornice.

Blocking Out (*Photo.*) Covering parts of the negative with an opaque paint or varnish in order that they may appear white in the print.

Blocking Press (*Bind.*) A machine used for impressing ornamental designs on cloth covers.

Block Joint (*Plumb.*) A wiped joint (*q.v.*) with a flange, used for large lead pipes when in a vertical position.

Block Setting Crane (*Eng.*) A powerful travelling crane (*see* CRANES) used in setting heavy masonry, such as harbour work or bridge piers.

Block System (*Railway Eng.*) The system of signalling used on English passenger railways. The line is divided up into sections, each beginning and ending with a semaphore signal. A train may not enter any section while another train or any part of a train is on it. When no train is on a section, it is said to be "clear"; the signal at the beginning of the section may then be put down or "set at clear" as soon as a train approaches, and the driver can enter the section at once. It is obvious that as long as the Block System is working correctly there is no risk of collision between two trains running in the same direction on the same line of metals; but it does not secure absolute immunity from accidents. Indeed, probably no system of signalling can achieve such a result. For example, if an "up" train became derailed or wrecked, it might obstruct the "down" line, and the signalman would have no indication that the down line was not clear; and if he admitted a train to it, as he would be justified in doing from the information at his command, an accident to the down train would occur.

Block Tin. Tin of second quality, usually cast in ingot or block weighing about 3 cwt. The best quality is known as Refined Tin. *See also* TIN.

Blood (*Zool.*) It consists of a clear fluid (plasma) containing red and white corpuscles. The former are round discs of a yellowish tint, and serve to carry oxygen in combination with their pigment (hæmoglobin); the white corpuscles are amœboid,

colourless, and few in number. Blood is used in various manufactures—*e.g.* in calico printing, in the manufacture of prussiate of potash, and in sugar refining. *See* HÆMOGLOBIN *and* WASTE PRODUCTS: ANIMAL REFUSE.

Bloodstone (*Min.*) A variety of CHALCEDONY of dark green colour, speckled with red; it is also called HELIOTROPE. Much used for seals and rings. *See* PRECIOUS STONES.

Bloom (*Leather Manufac.*) Bloom is ellagic acid, a greyish powder which deposits on the leather in the tan pits. It is practically insoluble in water, and separates out in the tan liquors. *See* BLOOMED BUTT.

—— (*Met.*) The mass of iron taken from the puddling furnace (*q.v.*) after squeezing to expel cinders; also any piece of iron prepared for the hammer or rolling mills.

Bloomary *or* **Bloomery** (*Met.*) The first forge through which iron passes after it has been melted from the ore, and in which it is made into blooms.

Bloomed Butt (*Leather Manufac.*) A butt (*q.v.*) finished with the bloom left in. Chiefly manufactured from South American hides. Originated in and is still chiefly confined to West of England.

Blooming (*Dec.*) A defect in varnish or varnishing giving rise to a mist or bloom which appears upon the bright surface, and dims it wholly or partially. The trouble arises from moisture or a want of ventilation. Can be temporarily cured by rubbing over the surface with a rag moistened in paraffin oil.

Blooming Mills and Rolls (*Met.*) The machinery used in dealing with the bloom of puddled iron.

Blottesque (*Paint.*) Painted in large blots. *Spectator*, January 24th, 1885: "The fashionable blottesque school wherewith modern painters smear their way to 'emolument and oblivion.'"

Blow (*Met.*) In smelting, the forcing of air into the furnaces. In the foundry a blow, or blowhole, is a cavity caused by air being enclosed in the molten metal.

Blower (*Mining*). (1) A jet of natural gas emanating from coal in a mine; (2) blowing machinery for pumping air.

Blowing Engines (*Eng.*) Either rotary machines (*see* FANS) or large pumps, worked directly from the piston rod of an engine. Used for working the air blast. They deliver large volumes of air at a pressure of 2 up to 10 lb. per square inch.

Blowing Off (*Met.*) Driving out the whole of the water in a boiler, in order to expel the sediment.

Blowing Room (*Cotton Spinning*). That department of a spinning mill where opening and scutching (*q.v.*) are carried on.

Blowing Through (*Eng.*) Clearing the pipes and valves of an engine by sending a current of steam through before starting.

Blown Castings. Castings containing a number of blowholes.

Blown In (*Met.*) A blast furnace fully started. This operation takes three or four weeks.

Blown Joint (*Plumb.*) A lead pipe joint made with a blowpipe.

Blown Oil. A fixed oil (*q.v.*) such as linseed or rape oil, which has been treated by being heated and having air blown through it. The process increases the density and viscosity of the oil, and renders it valuable in the manufacture of lubricants, for which purpose it is usually mixed with a mineral oil.

Blown Out (*Met.*) A blast furnace which has been stopped is said to be "blown out."

Blown Sand (*Geol.*) A term applied to the deposits of sea sand which accumulate on the shore just above high water mark in many maritime areas, and form sand dunes. Part of the sand is blown inland in the dry state; but most of it is transported in sea spray driven landward during storms. The water drains back to the sea, and the sand is left. Much rearrangement is afterwards carried out by the action of the wind when the sand is dry.

Blow Off Cock (*Eng.*) A cock at the lowest part of a boiler used for emptying it by blowing off.

Blow Out (*Mining*). A part of a vein which has become decomposed.

Blowpipe. A curved tube with a fine aperture, used to direct a jet of flame on to an object which has to be heated. Used in chemistry for dry tests, and in various arts. In the latter case a portable lamp is frequently combined with the blowpipe, and in this form it is used for soldering by plumbers, electric wire men, etc., and by painters for burning off old paint before applying a new coat. The air current is furnished either by the breath of the operator, by some form of blower or bellows, or by the use of compressed oxygen. The latter furnishes the most intense flame known, and will fuse many of the most refractory substances, being second only to the electric furnace (*q.v.*) in the temperature which it can attain.

Blowpipe *or* **Blowing Iron** (*Glass Manufac.*) A long hollow iron rod about 5 ft. in length and varying in diameter from ⅝ to 2 in. according to the weight of the glass intended to be worked.

Blow Through Valve (*Eng.*) A valve connecting the valve box with the condenser of an engine, used for blowing through (*q.v.*) before starting the engine.

Blubber (*Zoology*). A layer of thick, oily fat beneath the skin of the whale and porpoise. Large quantities of whale oil are obtained from it.

Blubber Oils. A group of oils obtained from the blubber of the whale, seal, porpoise, and dolphin (black fish), *q.v.*

Blue (*Paint.*) One of the primary colours: cf. the colour of the clear sky or the deep sea. The blues used as pigments are practically all compound substances derived either from vegetable or mineral sources. Amongst blue pigments may be mentioned ultramarine, Prussian, French, cobalt, royal, smalt, etc. (*q.v.*)

——, **Alkali.** *See* DYES AND DYEING.

Blue Billy (*Met.*) A ferruginous residue resulting from the roasting of copper pyrites, used as a "fettling" (*q.v.*) in the Cleveland iron district.

Blue Black (*Paint.*) Ivory black.

Blueing (*Eng.*) In tempering steel, the production of the blue tint by heating the metal to about 570° F. Steel springs, pistol barrels, etc., are so tempered.

Blue John (*Min.*) A miner's synonym for FLUOR-SPAR (*q.v.*)

Blue Lias (*Geol.*) A term usually restricted to the bands of argillaceous limestone which occur in the LOWER JURASSIC ROCKS.

Blue Lias Lime (*Build.*) A lime that will set under water—*i.e.* a hydraulic lime. *See* CEMENTS.

Blue Metal (*Met.*) A copper MATT (*q.v.*) containing 60 or 70 per cent. of copper.

Blue Print (*Photo.*) A mixture of a ferric salt and potassium ferricyanide is spread on paper; light produces an insoluble blue compound resembling Prussian blue. The unchanged portion can be washed away, giving (if a tracing is being copied) white lines on a blue ground. To get blue lines on a white ground the paper may be coated with certain ferric salts and developed in a solution of potassium ferrocyanide, and then cleared by an acid bath and washed. This process is less used than the former one, as it involves much more manipulation.

Blue Vitriol (*Chem.*) The common name for crystallised copper sulphate, $CuSO_4 5H_2O$.

—— (*Min.*) A synonym for CHALCANTHITE (*q.v.*)

Bluey (*Plumb.*) A slang name for lead.

Blunger (*Pot.*) A vertical cylindrical machine in which knives are fixed upon a rotating central shaft. The use is to cut up and to amalgamate with water such clays as do not require grinding.

Boarding (*Leather Manufac.*) A process used for light leather for *producing* the natural grain markings on the leather. The skins are boarded up (rolled) with a curved board covered with cork, which grips the damp leather.

Boarding (*Leather Manufac.*) *See also* GRAINING.

Boards (*Bind.*) Pieces of strong strawboard or millboard used to form the covers of books. A book *in boards* has these covered only with paper; if they are covered with cloth, it is *in cloth boards*; if with leather or a like substance, the book is *bound*. Formerly the boards were of thin wood; hence the name.

Boasted (*Build.*) The surface of a stone which has been worked with a chisel called a boaster.

Boaster (*Sculp.*) (1) A tool made of various materials, used in modelling clay or wax; (2) a broad-faced chisel used by masons for dressing the surface of a stone.

Bob (1) The weight on a pendulum, or the weight on a plumbline. (2) A counterbalance weight used in many pieces of machinery.

Bobbin (*Weaving, etc.*) An implement round which thread or yarn is wound in order to be wound off again with facility, as required, in weaving or sewing. It frequently takes the form of a wooden or metal cylinder with a flange or rim at one or both ends.

—— (*Plumb., etc.*) An elongated hard wood ball for driving through lead pipes, in order to prevent denting or collapse while the pipe is being bent or hammered. Also termed a "follower."

—— (*Woollen Manufac.*) An implement on which the yarn is wound either for warping or beaming.

Bobbin Net (*Lace Manufac.*) This is made upon the twist lace machine as invented by John Heathcote, 1809-11. It is a hexagonal-shaped net in imitation of Brussels, and has one system of threads traversed diagonally in both directions, with the result that it does not "run" when cut. Centres of manufacture, Nottingham, Tiverton, Chard.

Bodkin (*Archæol.*) A large pin or pinlike instrument, generally thicker than a pin, used by women for fastening coils of hair.

—— (*Typog.*) A pointed steel instrument used to pick out letters in set-up type.

Body (*Eng.*) Applied to oils. "Body" refers to the consistency or viscosity. An oil which owes its viscosity to resinous substances in solution should not be considered to have "body." A lubricating oil should have good body.

Body (*Typog.*) The shank of a letter.

Body Colour (*Paint.*) (1) Colour which coats or covers the canvas, being opaque by the addition of white instead of being transparent, or used as a wash.

—— *or* **Body of Pigments** (*Dec.*) The property of opacity or power to mask or hide a surface to which a pigment, in the form of a paint, is applied. It is this property which makes white lead so valuable as a paint. Body is sometimes incorrectly termed "covering power" (*q.v.*)

Body of a Work (*Typog.*) The text of a volume, exclusive of preface, notes, appendix, etc.

Boghead Coal (*Min.*) A synonym for TORBANITE (*q.v.*)

Bogie (*Eng.*) A frame carrying two or four wheels, attached by a vertical pivot to the front or back of a locomotive or long truck or car. The bogie can turn on this pivot when the vehicle is going round a sharp curve.

Bogie Engine (*Eng.*) A locomotive with a bogie either under the front or back of the frame of the engine.

Bog Iron Ore (*Min.*) A loose earthy form of LIMONITE often deposited in swampy ground, probably as the result of the decomposition of other iron compounds by decomposing vegetable matter. It is sometimes worked as an ore.

Bohemian Glass. *See under* GLASS MANUFACTURE.

Boil (*Met.*) The stage of the Bessemer process during which the carbon is being oxidised to carbon monoxide.

Boiled Oil (*Dec.*) Linseed oil which has been heated to a temperature of from 210° to 260° C. This increases its "drying" properties or power of absorbing and combining with oxygen. Various driers, such as litharge or manganese dioxide, are usually added in small quantities to the oil while hot to assist the quick drying. Boiled oil is generally mixed with raw oil when used by the painter. Refined boiled linseed oil is lighter in colour than the usual quality, and is valuable for mixing light paints, particularly zinc white (*q.v.*) A simple test for drying qualities is to paint a little of the oil on a watch glass. At the end of twenty-four hours the oil should have formed into a hard, glossy skin. Raw oil at the end of the same period will have remained soft. Unboiled oil is called "raw oil."

Boiler Capacity (*Eng.*) Either the cubical capacity of the boiler or the horse power of the engine it can drive.

Boiler Coating (*Eng.*) A non-conducting coating of asbestos, felt, cement of some kind, or some patented composition placed over boilers to prevent loss of heat.

Boiler Crown (*Eng.*) The top plate of a boiler.

Boiler Explosions (*Eng.*) The sudden bursting or rupture of the plates of a boiler; the serious consequences which ensue are caused not only by the violence with which fragments of iron, masonry, etc., are scattered in all directions, but also by the scalding steam, which proves fatal to persons exposed to it in an incredibly short space of time. Explosions occur through inherent weakness in the boiler itself, due to faulty construction; the use of inferior materials; plates having been corroded or eaten away by the action of the water; or owing

to an excessive increase of pressure caused by carelessness, overworking the boiler, or failure of the SAFETY VALVE (*q.v.*) Strict regulations for the management of boilers are laid down by the Board of Trade, and enforced by official inspectors.

Boiler Fittings and Mountings (*Eng.*) Those parts of a boiler which have to be added after the carcase leaves the hands of the boiler maker.

Boiler Plate (*Eng.*) Ordinary Lowmoor, B.B., or B.B.B. plates (*q.v.*) Steel plates are now much used, fastened with steel rivets, and as they can be made much larger than iron plates, the number of seams and rivets is greatly diminished.

Boiler Pressure (*Eng.*) Varies from 40 or 50 lb. per square inch to several hundreds in modern "tubular" and "water-tube" types.

Boilers. An engine boiler consists of a vessel made of wrought iron or steel plates riveted together at their edges, and is usually of cylindrical form. In the older forms of boiler the fire is contained in an inner tube, from which there may lead one or more flues, which serve the double purpose of conveying away the waste gases and of increasing the heating surface of the boiler.—A CORNISH BOILER (fig. 1) contains one large tube running through the boiler from end to end, carrying the grate at one end, the other end being connected to the chimney. This large tube is frequently crossed by short conical tubes termed GALLOWAY TUBES, which increase the heating surface, and also help to strengthen the large tube through which they run by acting as stays. One of these tubes is shown running through the fire box of the vertical boiler in fig. 3.—LANCASHIRE BOILER (fig. 2): This is similar in outward form to the Cornish boiler, but contains two large tubes running through it.—VERTICAL BOILERS: These are used in small engines, launch engines, fire engines, etc. They contain an internal fire box, as shown in fig. 3. This fire box is frequently crossed by Galloway tubes, one of which is shown in section in the figure. When very great heating surface is required, a device known as a FIELD TUBE is used. This consists of a tube closed at one end, running into the fire box, with a smaller tube open at both ends fixed concentrically inside it. Water can thus circulate through the tube on account of the double passage (*see* fig. 4).—LOCOMOTIVE BOILER: The essential characteristic of the locomotive boiler is the presence of a large number of flues, which are small tubes carrying the furnace gases from the fire box to a smoke box or receptacle communicating with the chimney. A diagrammatic section of a locomotive boiler is given in fig. 5. WATER TUBE BOILERS: In these boilers the fire box is external to the boiler. The latter consists of a very large number of tubes communicating at their ends with vessels intended to contain a certain amount of water and steam. The structure of a water tube boiler will be best understood by reference to the diagrams. Fig. 6 shows the YARROW WATER TUBE BOILER. A is a long cylindrical vessel communicating with two smaller ones, B, B, by a series of tubes, C. In ordinary use the water will reach up to the level shown, and the steam will collect in the space

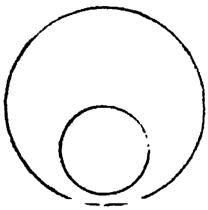


FIG. 1.—CORNISH BOILER.

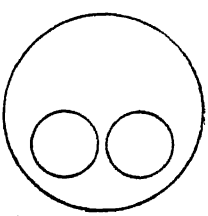


FIG. 2.—LANCASHIRE BOILER.

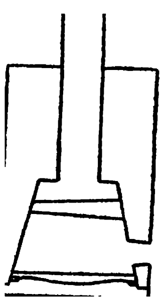


FIG. 3.—VERTICAL BOILER.

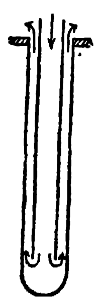


FIG. 4.—FIELD TUBE.

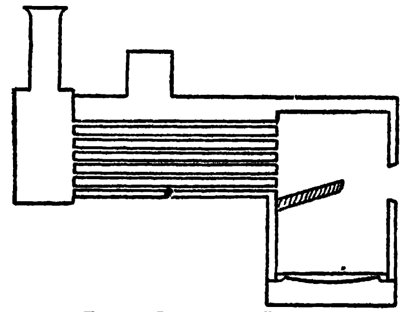


FIG. 5.—LOCOMOTIVE BOILER.

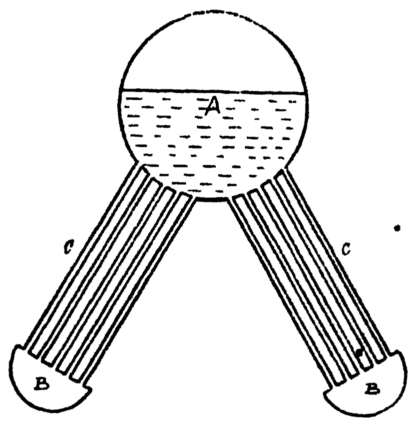


FIG. 6.—YARROW WATER TUBE BOILER.

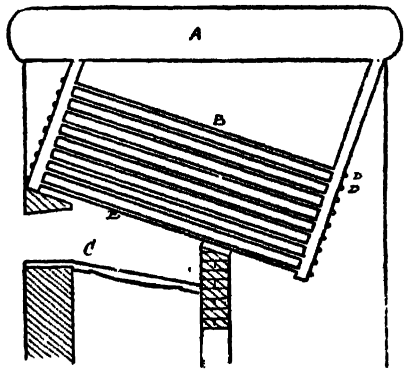


FIG. 7.—BABCOCK & WILCOX WATER-TUBE BOILER.

above. Fig. 7 is the boiler introduced by BABCOCK & WILCOX. A is the vessel where the steam collects; B, B are the heating tubes; C is the furnace. The tubes can be cleaned out by means of removable plugs, shown at D.—The BELLEVILLE BOILER consists of a number of steel tubes arranged in a vertical zigzag, which is spoken of as an "element" of the boiler. Each element communicates at one end with the vessel in which the steam collects, and at the other end with the adjoining element. One element is shown in elevation in fig. 8. In many cases an "ECONOMISER" is added to the Belleville boiler. This consists of a number of elements similar to those of the boiler, fixed in the "up take" or space above the boiler, through which the furnace gases escape. The feed water is caused to become heated in passing through the economiser on its way to the boiler proper.—FLASH BOILERS: These may be defined as small water tube boilers in which there is no vessel to contain a reserve of water and steam. A pump injects a small quantity of water into the boiler at each stroke, and this water is converted into steam almost instantaneously. The supply of steam to the engine is then controlled by regulating the amount of the feed water instead of by throttling the steam. One of the best known types is that of M. SERPOLLET. The tubes in this boiler are compressed, as shown in fig. 9; or in some cases they are twisted or curved after being compressed, as in fig. 10, in order that the amount of heating surface compared to the volume of water contained may be as large as possible. Serpollet boilers and others on a similar principle are used in steam cars on the road. As an example we may take the case of a four-seated car of 6 horse power. The boiler contained 95 ft. of steel tubing, with 25 sq. ft. of heating surface. The whole boiler was only 2 ft. 6 in. long by 1 ft. 6 in. broad, measured outside the case.

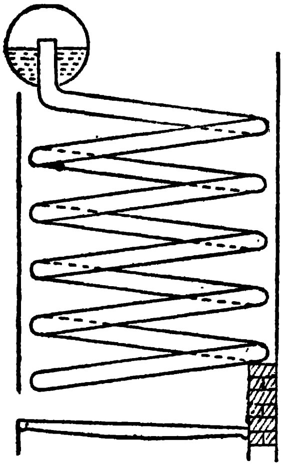


FIG. 8.—BELLEVILLE WATER TUBE BOILER.

9.—SERPOLLET TUBES.

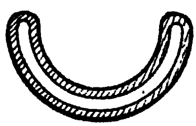


FIG. 10.—SERPOLLET TUBES.

Boilers (*Motor Cars*). These are of the water-tube or the flash types: the former suitable for heavy vehicles, such as steam lorries; the latter for light cars. *See also* BOILERS *and* MOTOR CARS.

Boiler Setting (*Eng.*) The masonry, etc., on which a boiler rests and which forms the flues.

Boiler Smithy (*Eng.*) A forge where the angle irons and other incidental ironwork of a boiler are prepared.

Boiler Stays (*Eng.*) Rods strengthening the shell. In many forms the tubes themselves serve as very efficient stays.

Boiler Testing (*Eng.*) Water is forced in under a high pressure, which is measured by suitable gauges. The use of water instead of steam in testing obviates the danger of an explosion; leakage is detected by a fall of the pressure gauge, and a tear or burst is at once noticed, but it will not be violent nor dangerous to the operators.

Boiler Tubes (*Eng.*) *See* BOILERS.

Boiling. (1) In the ordinary sense, the production of vapour throughout the mass of a heated liquid, which occurs, under normal pressures, at a definite temperature, called the "boiling point"; (2) in metallurgy, the purification of tin by immersing pieces of damp wood in the molten metal. The gases evolved cause the pure metal to collect on the surface, forming "refined tin."

Boiling Point (*Heat*). The temperature at which cavities or bubbles of vapour form within the mass of a liquid. The boiling point is raised by the presence of dissolved substances, and also by increasing the external pressure, and is lowered by diminishing the pressure.

Bole (*Bind.*) A fine kind of clay, containing iron oxide, used to prepare the edges of books for gilding.

Bolection Moulding (*Carp. and Join.*) A panel moulding (*q.v.*) projecting above the surface of the framing, which it decorates. Used chiefly for external doors.

Bollard. A short column fixed in the masonry of a quay for mooring vessels; also a similar column on the deck or bulwarks of the vessel.

Bolognian Phosphorus (*Chem.*) A name given to barium sulphide, obtained by reducing the sulphate by heating it with charcoal. If, after exposure to a bright light, it is removed to a dark place, it shows an orange phosphorescence.

Bolometer (*Elect.*) An instrument for detecting radiant heat. A zigzag grating of very thin platinum foil receives the rays; the rise in temperature produced alters its resistance, and upsets the balance of a Wheatstone bridge (*q.v.*), of which it forms one arm. It detects, rather than measures, radiation; but within certain limits the deflection of the galvanometer may be taken as a measure of the amount of radiant energy received by the grating.

Bolsover Stone. *See* BUILDING STONES.

Bolster (*Architect.*) The return part of the volute of an Ionic capital. *See* BALUSTER, ARCHITECTURE, ORDERS OF, *and* IONIC.

—— (*Eng.*) The part of a punching machine which supports the metal which is being worked upon.

Bolt (*Arms*). An arrow, especially a short, thick arrow that was used with the crossbow; this latter weapon was also termed a "quarrel."

—— (*Bind.*) The fold in the sheets at the head and foredge (top and front) of an "uncut" book.

—— (*Cloth Manufac., etc.*) A roll of woven fabric, varying in length according to the fabric, being in some cases 30 yards, in others 28 ells.

—— (*Eng., etc.*) (1) A general term for the screw with fixed head and loose nut used in fastening up metal or wood work; (2) an appliance for fastening a door, consisting of a piece of iron which moves

longitudinally through guides on the door, so that it can be shot into a socket in the doorpost; (3) that part of a lock which springs out and enters the receptacle or "keeper."

Boltant, *also* **Bolting** (*Her.*) Said of hares and rabbits when running.

Bolting (*Met.*) Closing up the "tap hole" of a cupola furnace with clay in order that a fresh amount of molten metal may accumulate.

Bolt Machine (*Eng.*) A machine for forging the blanks of bolts, ready for screwing or cutting the thread.

Bombardon. *See* MUSICAL INSTRUMENTS—WIND, BRASS.

Bombylios. A small antique vase with a very narrow neck.

Bond (*Build.*) The method of laying bricks or stones so that the vertical joint below is covered by the brick or stone above it. *See* DUTCH, ENGLISH, FLEMISH BOND, etc.

Bond Block (*Build.*) A bond in which a number of headers (*q.v.*) are laid side by side.

Bonder (*Build.*) A stone going threequarters through the thickness of a wall.

Bond Timber (*Carp.*) Timber fixed by being built in walls; wall plates, etc.

Bone (*Zool.*) The substance forming the skeleton of the body; it is composed of inorganic and organic matter in the proportion of 67 parts of the former to 33 parts of the latter. The inorganic matter consists of calcium phosphate, carbonate and fluoride, and magnesium phosphate. The organic matter is cheifly collagen, which on boiling is converted into gelatine. Bone is traversed by a network of canals carrying bloodvessels. The bones of various animals, chiefly those of the ox, are used in turning and in cutlery; also in the manufacture of charcoal or bone black. Bone ash is used in assaying. Bone preparations form excellent manures, owing to the phosphate of lime which they contain. *See also* WASTE PRODUCTS.

Bone Ash. The residue that remains when bones are strongly heated in air: a white powder consisting of calcium phosphate ($\frac{4}{5}$) and magnesium phosphate, calcium carbonate, calcium oxide and calcium fluoride, the last four substances together forming about $\frac{1}{5}$th of the bone ash.

Bone Beds (*Geol.*) A name which is now usually restricted to any band of rock which yields an unusually large number of remains of vertebrates, which in most cases are those of fish. One bone bed occurs in the Ludlow Rocks, near the town of that name; another occurs in the LOWER CARBONIFEROUS rocks of the coast of Fife, south of Kirkcaldy; a third is found in the Rhætic Beds near Aust, on the Bristol Channel.

Bone Black. The same as animal charcoal (*q.v.*)

—— (*Paint.*) A pigment made from carbonised bones. It mixes well with water and oil, and is quite permanent. The better grades of bone blacks are often sold as ivory black (*q.v.*)

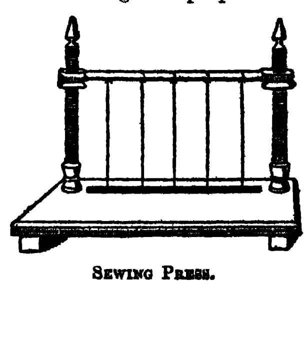
Bone Oil. When bones, freed from fat, are distilled in iron retorts, gases are given off, and a distillate is obtained which separates into a watery part, rich in ammonia and its compounds, and an oil called bone oil, having a disagreeable smell and a dark brown colour. This oil is a complex mixture of Amines (*q.v.*), Nitriles (*q.v.*), Pyrrol (*q.v.*), Pyridine and its homologues (*q.v.*), Quinoline (*q.v.*), and other less important constituents. *See also* WASTE PRODUCTS.

Bone Turquois (*Min.*) Fossil osseous remains coloured by phosphate of iron. Also called ODONTOLITE. It is used as a substitute for TURQUOIS.

Boning Staves *or* **Rods** (*Surveying*). Used in levelling. Staves, usually 3 ft., furnished with T-head.

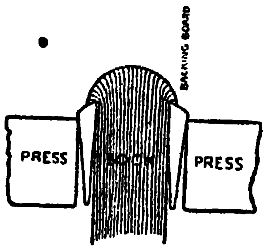
Bonnet (*Eng.*) (1) The cap or cover of the valve box of a pump; (2) the cover or hood of a forge; (3) the cover placed over the engine of a motor car, usually pierced with parallel slots to allow the free play of air round the engine to aid in the cooling; (4) any case or cover in engineering.

Bookbinding. Before the invention of printing, the manuscript books, which were chiefly of an ecclesiastical character, were bound by the monks. Owing to the great amount of labour involved in producing these books, they were highly valued, and the binding or cover of a book was frequently richly ornamented with gold and silver work—sometimes even jewelled. Binding in this style is known as "Byzantine." By the end of the fifteenth century bookbinding had become an art by itself, although it was probably in the workshops of the early printers themselves that binding was executed. In addition to royal patrons of the art, the most celebrated bibliophiles or collectors of books during the sixteenth century were Maidli, Grolier, and De Thou; and doubtless the books forming their respective libraries were bound immediately under their supervision. Howbeit, in these and other early instances, bindings are known by the names of their collectors and not by the names of the actual binders. Amongst celebrated binders employed in the royal service in France, where the art was so ardently cultivated in the sixteenth century, were Nicolas and Clovis Eve. In the seventeenth century the most celebrated artists in the profession were Le Gascon and Du Sueil, the former noted for his *pointillé* work—innumerable minute dots in geometrical arrangement. Later come Padeloup and Derôme. In England one of the binders in the reign of Henry VII. whose name has been handed down is Julian Rotary, and in the following reign there was one John Reynes. Two and a half centuries later we come to Roger Payne, one of the best English binders; while later still Baumgarten, Kalthoeber, Bohn, and others have left examples of work which place them in the first rank. To come to present-day work, a book properly bound passes through twenty-three distinct and different processes, but each process might be again divided and subdivided. The book, when it comes from the printers, is first folded, or, if it has been previously bound in cloth, it is "pulled" or taken to pieces. Next it is collated—that is, the sheets arranged in proper order and ascertained to be perfect, and the plates, if any, pasted in their places. It is then rolled or pressed, and afterwards sewn. In sewing, each sheet is fastened to cords by a thread going along inside the fold of the back, the ends of these cords being

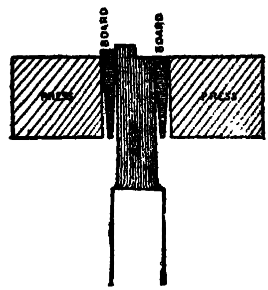


SEWING PRESS.

afterwards laced into the boards. Next, folded papers, plain or coloured, are placed on the front and reverse side, being edged on with paste. When these are dry, the cords are ravelled out and slightly scraped. The book is now put into a laying press between a pair of firm millboards, the back standing up about 2 in. above the cheeks of the press. Three or four books of the same size may be put in at one time. The back is then glued over with thin glue, and the book taken out of the press and left to dry. It is next rounded and backed. For backing it is placed in the laying press, between a pair of bevelled boards, called backing boards, the rounded back standing up above the boards and showing a margin of the end papers as wide as the thickness of the millboards about to be used. The press is then screwed up tightly, and the book is backed by striking the back with the hammer, gently at first, commencing in the middle and beating the back down to the bevelled boards, first on one side, then on the other, the back being finally modelled into a good shape. The next process is to cut the boards. Having been roughly cut with the large shears, somewhat near the size of the book, they are squared with the plough just a little larger than it is intended to cut the book—the standing rule in good work being to leave every book as large as possible. When the boards are cut to size, they are placed one on each side of the book, and a mark is made where the cords come. Then holes are pierced through these marks, the board is turned over, and other holes pierced about a quarter of an inch away from the first holes. The ravelled out cords or slips are then pasted and twisted to a point with the finger and thumb, so that they can easily be passed through the holes—in at the first hole and out at the second. They are then drawn tight and the surplus ends cut off. The next step is to rivet the cord by hammering it smooth on the knocking-down iron—an iron casting with an even surface made to fit in the laying press. The book, after being rounded up and put into good shape, is put into the standing press, screwed up as tightly as possible, and generally left in till the next day. Before it is taken out of the press the back is pasted over with thin paste and rubbed smooth, then wiped dry with a handful of paper shavings. Some perform this operation as soon as the book is put into the press; but when the pressure is removed from the mass of paper forming the book, it naturally rises somewhat, in consequence of being dry, and frequently the back cracks, whereas if the back be moist when the pressure is taken off, the expanding mass of paper conforms to the new conditions upon being taken out of the press, without any danger of cracking. The book is next cut. First, the top edge, called the head; next, the bottom edge, called the tail; and lastly, the front edge, called the foredge. The cutting is done by lowering the front board as far down from the head as it is intended to cut, placing a thin piece of millboard between the back board and the book. Then it is lowered into the laying press until the top of the front board is even with the cheek of the press, which is then screwed up tightly, and the book is cut by working the plough backwards and forwards, the operator closing it as he pushes it away and opening it as he draws it towards him. The same operation is repeated in cutting the tail. In cutting the foredge, two trindles—flat pieces of steel or wood about an eighth of an inch thick—are placed between the back and the boards. The book is then lifted up between both hands, and brought down with some force upon the cheek of the laying press; the back, striking the press, becomes flat, the trindles keeping it in this position. A cutting board is then placed on each side, that on the front side being even with the line to be cut through, and that on the back raised a little above. The position for placing the cutting boards is regulated by drawing a line with a sharp point or pencil on the end papers along the front edge of the boards on each side, and the book is cut as much below this line as it is desirable to have the boards projecting beyond. It is then lowered in the press, after taking out the trindles, bringing the front cutting board even with the cheek of the press, and cut with the plough in the same manner as the head and tail. When taken out of the press, the back resumes its round shape again, and the foredge will be the reverse of the back. The next process is to decorate the edges. They may be sprinkled red, brown, or blue, or coloured red or yellow, or indeed any colour; or they may be marbled or gilded. Next, the book is headbanded. A very narrow strip of stiffened vellum or glued cord is fastened to the back of top and bottom edges by means of silk or cotton of various colours being twisted round the same and fastened to the back at short intervals. Then the back is lined with brown paper and thin strips of leather glued on to form bands, or it is simply glued over, and is now ready for covering. This is perhaps the most critical operation in bookbinding. The leather having been cut to the size, the edges are pared with a sharp knife just where they will be turned in by the headband—not all round. The cover is now pasted smoothly all over, and allowed to soak for a short time while the boards are being placed in position, etc. It is then placed upon the workboard, pasted side uppermost, and the front side of the book laid upon it, care being taken that an even margin of leather is left round the three edges. Then the other end of the cover is lifted up and drawn over the back edge, being smoothed out carefully with both hands. The board is now lifted and the margin of leather on the foredge is turned over on to the inside of the board with the forefingers and thumbs of both hands. The book is then turned over and the operation repeated on the other side. Next, the book is held in the left hand and the boards allowed to fall open on the workboard, and, being brought to the edge of this, the margin of leather, head and tail, is also turned over on to the inside of the boards with the finger and thumb of the right hand, beginning at the headband, in which place it is turned over on to itself; and to accomplish this it is necessary to raise the book somewhat away from the boards. The edges of the boards are then made



AFTER BACKING.

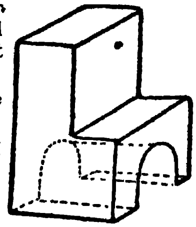

SECTION OF BOOK AND PRESS. FOREDGE PARTLY CUT.

smooth and sharp with the folding stick. There will then be some surplus leather at the corners. To get rid of this it is pinched together with the finger and thumb, or both thumbs, and then cut through with the shears and smoothed down with the folding stick, one edge lapping slightly over the other. When dry—generally the next day—these two layers of leather are cut through with a sharp knife at an angle of 45, the surplus pieces taken away, and the two sharp edges pasted and carefully joined. The next process is to trim the inside margin of leather round the three edges of the boards, and fill in the centre space with thick paper, making it level with the rim of leather. The end papers are then pasted down to the boards, care being taken to leave an even margin of leather round the three sides: and the book is bound. Then follows the decoration, or, as it is called, the finishing, the only *necessary* part of which is the lettering. The finisher's first process is marking up. He makes certain marks upon the leather to guide where lines or tools are to be impressed. Then the leather is carefully washed over with vinegar if it be morocco, or paste water if it be calf; and when dry, a coating of albumen is laid on wherever the gold is to appear. If the back is to be "full gilt," then the albumen is sometimes put on with a sponge—always, in the case of calf; if only lines each side of bands, then the albumen (glacé) is put on with a camelhair pencil. When dry, the gold is cut on the gold cushion to the size required, and the part to be finished is well greased with oil, lard, or vaseline, according to the leather. Then the gold is taken off the cushion with a pad of cotton wool, which has been previously dabbed on the hair to cause the gold to adhere temporarily to the pad, and then placed on the part about to be finished, and well dabbed down with the pad. The book is now put into the finishing press, the back standing out a little above the cheeks. The lines and flower or scroll tools, having been heated at the stove or gas pan, are now impressed on the back over the gold. Afterwards the surplus gold is wiped off. The book is now lettered. The panel or part where the lettering is to appear having been glaired and greased, the gold leaf is taken up with the pad as before, and laid all over it. Then, the book being in the press with the back standing a little way out, the head away from the workman, a fine thread is drawn across the gilded panel. This makes a fine dark line upon the gold. As many lines are drawn as there are lines of lettering. The letters, having been heated at the stove, are impressed on the leather singly, the top of the letter being placed *just under* the line. Great care is necessary to ensure an equal pressure upon each letter. The lettering may be done with type. In this case a line of lettering is completed in one impression. The surplus gold is wiped off with the gold rag, and the surface cleaned with indiarubber. The sides of the book may be quite plain or finished elaborately. In the latter case it is usual to impress with all the tools before washing up for glairing, and glair with a camelhair pencil over the impressions. The gold is then laid on with grease, and the tools impressed through the gold—surplus gold wiped off as before. The whole is then polished with a moderately warm polishing iron. The book is then placed in the press between japanned plates or bright smooth tins, and left in, if convenient, till the next day. Ordinary cloth bindings, in which books are issued by the publisher, are much simpler than the above. In these the book is sewn by hand or machine, glued up and rounded and generally backed, but not always or necessarily. It is then pasted into a case which has been made quite separately, and in which it is simply held by the end papers and a thin strip of cotton called mull.—R. De C.

Boom (*Eng., etc.*) Any long beam, especially the long, solid parts of a built-up girder.

Booster (*Elect. Eng.*) A subsidiary dynamo, used to keep the voltage at some part of the circuit remote from the principal dynamo, up to some constant value. The purpose of employing a booster is to obtain independent control of the voltage at some point or points of the circuit without alteration of the voltage of the main dynamo. The booster is often so adjusted as to automatically maintain constant voltage at some distant point of the circuit; often also to provide varying voltage, as for storage battery work.

Boot Boiler (*Build.*) A boiler fitted in a range. It is shaped like a boot, with the top part at the back of the fire.



Boot Boiler.

Boracic Acid (*Min.*) Native boracic acid occurs as a scaly crystalline deposit around fumaroles, marking the subsidence of volcanic activity in a district. The crystals are minute, of the triclinic system, and give a peculiar unctuous impression when rubbed between the fingers. From Lipari, Tuscany, Sienna, Atacama, etc. Composition: $B(OH)_3$. *See also* Boron Compounds (*Chem.*)

Boracite (*Min.*) A borate and chloride of magnesium, $6MgO . MgCl_2 . 8B_2O_3$ (boracic acid = 62·6, magnesia = 26·8, magnesium chloride = 10·6 per cent.) It occurs in cubic crystals of considerable hardness embedded in Anhydrite, in Hanover; it also occurs massive (*q.v.*) in the salt mines of Stassfurt.

Borates (*Chem.*) Salts of boric acid (*q.v.*)

Borax (*Min.*) Sodium biborate, $Na_2B_4O_7 . 10H_2O$; boracic acid, 36·6; soda, 16·2; water, 47·2 per cent. It crystallises in prisms of the monosymmetric system; it is largely used as a flux (*q.v.*) and in the manufacture of glass and of artificial gems. It occurs chiefly in Thibet (whence it is exported as Tincal), Persia, Tuscany, Peru, and various parts of North America. *See also* Boron Compounds.

Bordering Wax (*Engrav.*) A composition employed to make a raised border or rim round a plate of metal so as to retain the acid used for biting in during the process of etching.

Bordure (*Her.*) A band which entirely surrounds the shield, and is one-fifth of the field in width: the mark of difference of a younger son.

—— **Compony** *or* **Gobony** (*Her.*) Is composed of a metal and colour alternately.

Bore (*Eng.*) The internal cavity of a pipe or hollow cylinder.

—— (*Marine*). Any very marked and sudden rush of the tide up an inlet.

Boring (*Eng.*) Making, or finishing, a circular hole or "bore."

—— (*Mining, etc.*) A small hole, made by a drill of some form, to ascertain the nature of rocks below the surface, or for introducing a blasting charge.

Boring Bar (*Eng.*) A long rotating bar carrying a "boring head" or holder for the tool used in boring circular holes. In some cases the head can "traverse" or move along the bar; in others, the head is fixed to the bar, and the work has a slow longitudinal motion to produce the "feed."

Boring Machine (*Eng.*) Any machine for boring or for driving a boring bar. A self-acting lathe can be utilised as a boring machine by mounting and rotating the boring bar between the centres, and bolting the work to the saddle of the slide rest.

Boring Tool (*Eng.*) A tool resembling a turning tool mounted on a boring head and bar; sometimes applied to some form of drill for wood or metal. *See* BORING BAR, DRILL.

Borneo Camphor. *See* CAMPHOR.

Bornite (*Min.*) A synonym for ERUBESCITE (*q.v.*)

Boron, B. (*Chem.*) Atomic weight, 11. This element is not found native, but occurs in various combinations in the minerals boracic acid, borax, boracite (*q.v.*), ulexite ($NaCaB_5O_9 . 8H_2O$), priceite ($5CaO . 6B_2O_3 . 9H_2O$), pandermite, datholite, etc. It is a light maroon-coloured powder; burns at a high temperature in air, forming boron oxide (B_2O_3) and boron nitride (BN); latter compound also formed when it burns in nitrogen, which it does at a high temperature. It is a very powerful reducing agent, reducing metallic oxides when heated with them more readily than carbon. It is obtained by heating the oxide with magnesium powder at a high temperature and treating the product in succession with water, hydrochloric acid, water, alcoholic potash, water, hydrofluoric acid, water; once more heating with a little oxide and again treated as above. Said to have been obtained crystallised, but crystals probably impure. It is a non-metallic element belonging to the aluminium group in the periodic system.

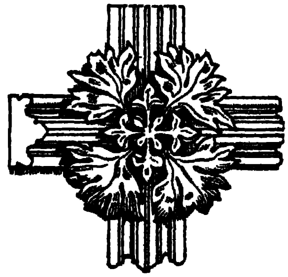
Boron Compounds. BORON HYDRIDE, BH_3, a gas, not known pure; burns with green flame, and obtained when alloy of boron and magnesium is treated with hydrochloric acid. BORON NITRIDE, BN, an infusible white powder obtained as under boron and also by heating anhydrous borax with ammonium chloride. It is decomposed by steam, giving ammonia and boric acid; according to some this is the source of the boric acid of the hot springs from which the acid is obtained. BORON OXIDE, B_2O_3, a white hygroscopic solid obtained by heating boric acid. Heated with salts of metals, the acid of the salt is expelled and the oxide dissolves in the boric oxide, often giving a characteristic colour; hence the use of borax in testing by the "borax bead." BORIC ACID, H_3BO_3, crystallises in plates; is soluble in water. On careful heating gives first metaboric acid, HBO_2, and then pyroboric acid, $H_2B_4O_7$. It is one of the weakest acids; it turns turmeric paper brown. It gives a green flame in the Bunsen burner. A solution in glycerine, called boro-glyceride, is used in medicine as an antiseptic. Boric acid is an antiseptic, and is much used as a food preservative. It is obtained by condensing the jets of steam (*soffioni*) of volcanic origin, which arise from the ground in parts of Tuscany. The steam contains traces of boric acid. The condensed steam is evaporated by the natural heat of the *soffioni*. It may also be obtained by acidifying a strong solution of borax with hydrochloric acid. BORAX, $Na_2B_4O_7 10H_2O$, a white crystalline solid soluble in water. Solution is alkaline. Readily decomposed by acids. It is an antiseptic. Extensively used as a preservative and in making glazes of many kinds. It is a derivative of pyroboric acid.

Bort (*Min.*) A black massive variety of diamond. A native form of carbon. It is useless for jewellery, but is very extensively used in the cutting and polishing of gems and in rock boring, the boring tools being armed with fragments of it. From South Africa, India, Brazil, etc.

Bosh (*Forging, etc.*) A trough in which "bloomary" tools are cooled. The same name is used for the trough in which hot ingots of copper are cooled.

Boshes (*Met.*) *See* FURNACES.

Boss (*Architect.*) An ornament, usually carved, formed at the intersection of the ribs of either a vaulted or a flat ceiling. The same name is also given to the ornament which frequently terminates a dripstone. *See* RIB AND PANEL VAULT *and* HOOD MOULD.



BOSS (DECORATED).

—— (*Bind.*) A metal ornament fastened on the covers of books either for decorative purposes or to preserve them. In early times the "umbo," a round knob, occupied the centre of the cover.

—— (*Eng.*) (1) The central part of a wheel, etc. (2) A projection intended to carry a shaft, projecting pin, or other added part of a machine.

—— (*Gasfitting*). A brass ferrule with an internal thread to screw a gas tap into.

Bossing (*Plumb.*) To work sheet lead into trays, gutters, and cesspools out of one piece of lead by turning up the sides, ends, etc., without cutting, soldering, or burning.

Bossing Mallets. Round tapered mallets for "bossing up" sheet lead or hammering it into any required shape.

Bossing Up (*Eng.*) Forming a raised part on sheet or solid metal by hammering or forging.

Böttcher, *also* **Böttger Ware** (*Pot.*) A hard ware like red jasper, manufactured at Meissen, Saxony, polished by the lapidary's wheel, and called after the manufacturer, Johann Frederick Böttger (1682—1719), who also discovered the method of making true hard porcelain in imitation of the Chinese.

BÖTTCHER WARE MARK.

Bottega. Italian word equivalent to "shop"; applied to the place where Italian artists used to paint their pictures and instruct their pupils.

Botteroll, *also* **Chape** *or* **Crampelle** (*Her.*) The piece of iron protecting the point of a sword or dagger sheath.

Bottle Glass (*Glass Manufac.*) This is manufactured from a mixture of the silicates of aluminium, calcium, and sodium which are readily fusible; but the glass is deficient in purity and lustre.

Bottle Jack (*Eng.*) A light screwjack (*q.v.*) whose external form resembles that of a bottle.

Bottle Nose Drip (*Plumb.*) A drip or step in roofwork, formed with a rounded edge.

Bottle Nosed Step (*Build.*) A step with a rounded edge and end.

Bottling Up (*Eng.*) The collection of steam in tubes or pipes when it is being produced too fast to escape to the steam chest or spaces above the water level of a boiler.

Bottom Bars (*Lace Manufac.*) A series of steel bars that work in a lower position than the ordinary or "top bars." They are used to measure the capacity of the machine in the production of "design."

Bottom Board (*Mould.*) A board used to hold up the lower part of a mould while sand is being rammed in round the pattern.

Bottom Bracket (*Cycles*). *See* CYCLES.

Bottom Card (*Eng.*) An indicator diagram (*q.v.*) taken from the lower end of a cylinder.

Bottom Face (*Mould.*) The part of a mould or casting which is at the bottom during the operation of casting. The bottom face is always the soundest part of a casting.

Bottoming (*Eng.*) The rubbing of the points of one gear wheel into the bottom of the spaces between the teeth of the other wheel; prevented by allowing sufficient bottom clearance.

Bottoming Tap (*Eng.*) A tap (*q.v.*) with the thread carried right to the end, in order to cut a thread right to the bottom of a hole.

Bottom Rail (*Carp. and Join.*) The lowest rail of a piece of framing, door, sash, gate, etc.

Bottoms (*Met.*) The residual alloy containing various impurities when fine metal (*q.v.*) has been roasted in the manufacture of copper.

Bottony, *also* Botoné (*Her.*) *See* CROSS TREFFLED.

Boulder Clay (*Geol.*) Properly applied to the clay which was formed by the direct action of ice during the Age of Snow, and which contains a heterogeneous mixture of stones which have been derived from many sources and are quite unsorted in regard to size. Many of the stones or boulders show the striæ characteristic of glacial action. Most boulder clay is now regarded as having been formed englacially—*i.e.* as representing material which was formerly dispersed throughout the lower part of the ice, and has been melted out of it as a kind of sediment.

Boulders (*Geol.*) A term somewhat loosely applied to any large blocks of stone which have found their way to some distance from the parent rock. Those which have been detached by weathering and have travelled downhill under the influence of gravitation are often usefully distinguished as TUMBLERS; and the term BOULDER is applied by the best authorities only to stones whose transportal has been effected by the agency of ice, more especially during the Age of Snow or the Glacial Period.

Boulevard. Originally meant the bulwark or rampart of a fortified town; now used of an avenue or of a walk encircling a town.

Bourdon's Gauge (*Eng.*) The instrument for measuring steam pressure. It consists of a length of tube of oval section closed at one end and bent into a curve. On steam being admitted, the tube tends to straighten itself, and the amount of movement, which is shown by means of a pointer and a dial, indicates the pressure of the steam.

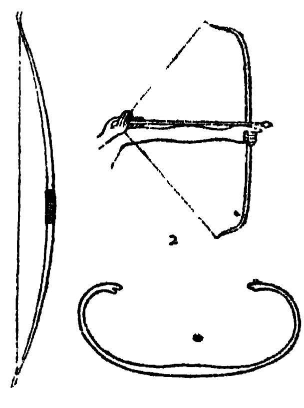
Bourgeois (*Typog.*) Type one size smaller than long primer and one size larger than brevier.

Bournemouth Beds (*Geol.*) Middle Eocene strata of marine origin, typically developed near the town of that name on the South Coast of England. They have yielded an important suite of fossil plants.

Bournonite (*Min.*) A sulphide of copper, lead and antimony, $3(PbCu_2)S . Sb_2S_3$; copper = 12—15, antimony = 24—29, lead = 39—43, sulphur = 18—20 per cent. Also called ENDELLIONITE, WHEEL ORE, or RADELERZ. The latter name is from the spokelike arrangement of the twinned rhombic crystals. Sometimes massive. Cornwall, Saxony, Harz, Chili, Bolivia, etc.

Bovey Tracey Beds (*Geol.*) Beds of lignite, occurring in Devonshire, which have yielded an extensive suite of vegetable remains, the general facies of which indicates that they are of late Oligocene or early Miocene age.

Bow (*Arms*). The bow has been used as a weapon of war and for purposes of sport as far back as there is any record, though naturally it varied greatly in shape. Among ancient nations the Assyrians, Egyptians, Parthians, Scythians, Persians, Thracians, and Cretans were most addicted to this weapon. In the Roman army the bow did not form part of the equipment of the regular legionaries. It was in the hands of the English archers, however, during the period extending from Edward III. to Henry V. that the bow reached its greatest perfection as a weapon of warfare, the deadly "cloth-yard" shaft doing terrible execution in the battles in which the English participated. Archers formed part of the English army long after the use of gunpowder was introduced—that is to say, down to the time of James I.; and Charles I. attempted to revive archery for purposes of warfare. At the present day the Persians, Tartars, Chinese, the Bushmen of South Africa, the South Sea Islanders, and the South American Indians are amongst those who use the bow either for sport or warfare.



1 ENGLISH BOW. 2. EGYPTIAN BOW. 3. PHRYGIAN BOW.

Bow China. The Bow China Works were established about the year 1743 at Stratford-le-Bow, near London, under the management of Thomas Frye, a well known mezzotint engraver. The factory and business were sold to Mr. Duesbury, of Derby, in 1775. Bow China is interesting, but it never attained the high standard of beauty and excellence achieved by Worcester, Chelsea, or Derby. A special feature of Bow China is its soft and creamy glaze. Bow figures, of which a large quantity were produced, are quaint in style, and the colouring is frequently clear and brilliant. For Pottery Marks, *see under* POTTERY.

Bow Compasses. Small draughtsman's compasses, in which the legs are connected by a stiff but flexible band of steel instead of a hinge. The angle to which the compasses are opened is controlled by a screw. Also termed SPRING BOWS and SPRING COMPASSES.

Bow Drill (*Eng.*) A light drill rotated by a string which is wound round a bobbin on the drill shaft, the ends of the string being attached to a bent bow of wood or steel.

Bowed (*Her.*) Bent like a bow: embowed.

Bowling Iron (*Met.*) Iron produced by the Bowling Company, Yorkshire; resembles Lowmoor iron in quality.

Bows. *See* BOW COMPASSES.

Bow Saw. A narrow saw fixed to a wooden frame, in which a twisted cord keeps the saw in tension. Used for cutting curves.

Bow's Notation *or* **Henrici's Notation** (*Eng.*) A method of denoting forces in graphical calculations: specially useful in dealing with reciprocal figures. *See* GRAPHIC STATICS.

Bowstring Girder (*Eng.*) A built-up girder with one straight boom, to the ends of which a curved boom is attached, the two thus forming an arc and its chord; the space between the straight and curved parts is crossed by latticework to increase the strength of the structure. A good example exists in the girders by which the cantilevers are connected together in the Forth Bridge.

Bowtell (*Architect.*) A round moulding used in Gothic architecture. The old English term was "boltell," and the moulding was probably so called because of its resemblance to a bolt. *See* ROLL MOULDING, SCROLL MOULDING, *and* KEEL MOULDING.

Box Calf (*Leather Manufac.*) Calf skins tanned by means of chrome salts, called "box" by reason of square markings on the grain: produced by rolling the skin, when in a damp state, from tail to nose and then from flank to flank.

Box Coupling (*Eng.*) A hollow cylindrical coupling or joint fitting over the ends of two pieces of shafting and connecting them so that they rotate together.

Box End (*Eng.*) The end of a connecting rod which is forged solid, a slot being made to receive the brasses, instead of their being attached by a strap keyed on.

Box Girder (*Eng.*) A hollow girder, built up of four strips of iron which form a cavity of rectangular section.

Box Gutter (*Build.*) A gutter with vertical sides, parallel in width the whole of its length.

Box In (*Typog.*) A term indicating that rules should be placed round as a border.

Boxing Shutters (*Carp.*, *etc.*) Window shutters that fold back into boxes.

Boxing Up (*Pattern Making*). Building up large patterns from boards instead of cutting them from the solid wood.

Box Metal (*Eng.*) Alloys used for bearings, including brass, gunmetal, white metal, etc.

Box Nut (*Eng.*) A nut with a cover which protects the end of the bolt from injury, rusting, etc., in exposed situations, thus preventing jamming of the nut on the end of the bolt.

Box of Tricks (*Cotton Spinning*). *See* BUILDING MOTION.

Box Spanner (*Eng.*) A spanner for turning nuts which lie in a cavity sunk below the general surface of the metal.

Box Stones of East Anglia (*Geol.*) Septarian nodules which contain water in cavities in the interior. The cavities are due to partial solution of the original material.

Boxwood. *See* WOODS.

Boxwood for Engraving. Small narrow blocks of the wood are used; for large engravings the blocks are fastened together by size and screws. In the case of woodcuts intended for illustrated papers, and where expedition is necessary, the blocks can be separated and distributed to different engravers.

Boyle's Law (Mariott's Law). The volume of a gas is inversely proportional to the pressure if the temperature remain constant. This law is true only for a PERFECT GAS (*q.v.*), but it is approximately obeyed by all gases when not too near their point of condensation.

Boyle's Valve (*Ventilation*). This valve is designed to act as an outlet for the vitiated air of rooms. It is an iron box arrangement provided with valves, which are suspended on rods. The ventilator is fixed in the chimney. Back draught is prevented by the automatic closing of the valves when the pressure is greater in the chimney than in the room.

Brace (*Eng.*, *etc.*) A rod or bar connecting two points in a structure for the purpose of strengthening or stiffening it. It is always in tension; a similar rod in compression is termed a strut.

—— (*Tools*). A cranked tool used for holding and rotating a drill or bit.

—— (*Typog.*) The sign ⏞, used chiefly for connecting words, lines, or staves of music.

Bracelet (*Cost.*) A band worn upon the wrist or arm, sometimes plain, but more often enriched by the graver and by the addition of precious stones. Bracelets were amongst the earliest of personal ornaments, and although now worn almost exclusively by women, they were in earlier times worn by both sexes of the better class, and were very common amongst the earlier inhabitants of Britain.

Brachydiagonal (*Min.*) The shorter of the two horizontal axes in the Orthorhombic system (*q.v.*) It is designated by the letter *a*, and is usually regarded as extending from front to back when the crystal is correctly oriented.

Brachydome (*Min.*) The face of a prism of the Orthorhombic system which has its axis coincident with the brachydiagonal (*q.v.*)

Brachypinacoid (*Min.*) A face normal to the macropinacoid.

Bracket (*Eng.*, *Build.*, *etc.*) A term of very wide use, applied to portions of structures used for stiffening or supporting some other part.

—— (*Carp. and Join.*) In staircase work the curved pieces planted (*i.e.* fixed) on the outside of a cut string; also a term of very general application in woodwork.

——, **Lamp** (*Cycles and Cars*). A projection, either fixed or moveable, to carry a lamp, the latter having a socket which fits the projecting part of the bracket.

Bracklesham Beds (*Geol.*) Marine beds of Middle Eocene age, typically developed on the coast of Sussex.

Bract (*Botany*). A leaf in whose axil (angle) a flower arises. The term is, however, loosely used, and may be applied to any specialised leaf in the vicinity of the flower.

Bradawl. A tool for making holes for brads or small nails.

Bradford Clay (*Geol.*) One of the subdivisions of the Oolites, well known on account of the excellently preserved fossils it yields in the typical locality. It forms the lowest member of the Middle Oolites, and it underlies the Coralline Oolite or the local equivalent of that rock.

Brake (*Eng., etc.*) Mechanism for controlling or slowing down any machine. It usually acts on a wheel. A block cut to fit the circumference is forced into close contact by levers or screws, or a flexible band is pulled into close contact with the rim of the wheel (band brake). *See also* CYCLES, MOTORS, WESTINGHOUSE BRAKE, PNEUMATIC BRAKE, *etc.*

—— (*Plumb.*) The angles of the projection of a wall in a gutter around which the lead is bossed when a lead gutter is formed.

Brake Drum (*Eng.*) The cylindrical portion on which the brake block or brake band acts.

Brake for Measuring Power. *See* DYNAMOMETERS, MECHANICAL.

Brake, Friction (*Mechanics*). *See* DYNAMOMETERS, MECHANICAL.

Brake Horse Power, B.H.P. (*Eng.*) The power (*q.v.*) developed by an engine or motor, which is absorbed by a brake dynamometer; distinguished from the indicated horse power (*q.v.*) as being the amount of power which the engine can put out for useful purposes.

Brake Shoe (*Eng.*) A brake block; the portion which comes into actual contact with the wheel on which the brake is acting.

Bramah's Press (*Eng.*) *See* HYDRAULIC PRESS.

Bramley Stone. *See* BUILDING STONES.

Branch Drains (*Sanitation*). These are tributaries conveying the sewage, slop, and waste waters to the main or common drain. A manhole should be constructed where the branches join with the main drain. As much care is necessary in the laying and jointing of branches as in the case of the main drains.

Brandering (*Carp. and Plast.*) Pieces of wood about 1 in. square fixed to large timbers that have to be plastered. On these pieces of wood the laths which carry the plaster are nailed.

Brands. (1) Marks used to distinguish the qualities of various materials; they are very numerous, and must be sought in the directories to the various specific trades to which they refer. (2) Iron letters used for impressing marks on wood by heating and pressing on the wood.

Brandy. A spirit made by distilling wine. It contains about 48 per cent. of alcohol by volume, and small quantities of higher alcohols and the ethyl esters (*see* ESTERS) of propionic, butyric, venanthylic, and valerianic acids. The colouring matter is tannin (pale brandy) or caramel (brown brandy). Inferior brandies are not made from wine, but are manufactured from recipes of various kinds. In France the finest brandy is known as "cognac"; inferior kinds as "eau-de-vie." Under the Food and Drugs Act, 1879, it is a good defence to prove that the admixture of water has not reduced the spirit more than 25 degrees under proof. This corresponds to about 43 per cent. by volume of absolute alcohol. The addition of water and burnt sugar (for colouring) is the general method of adulterating brandy.

Branly's Coherer (*Elect.*) *See* WIRELESS TELEGRAPHY.

Brasque (*Met.*) A carbonaceous mixture containing coal-dust, tar, etc., used for lining certain furnaces.

Brass. An alloy of from 63 to 72 parts of copper with 27 to 34 parts of zinc. It is of a yellow colour, hard, but so ductile that it can be drawn out into fine wire, though, when intended for converting into wire, it is often alloyed with small quantities of tin and lead. The manufacture of brass was only introduced into England in 1639, when works were established at Esher in Surrey. Brass is both tougher and more fusible than copper, and does not tarnish so quickly. The best brass is made by cementation of calamine or oxide of zinc with granulated copper. The name "brass" sometimes includes GUNMETAL (*q.v.*) Brass is used for many parts of machinery—*e.g.* where small and somewhat intricate castings are required, or a certain degree of finish for the sake of appearance, or especially as bearings for moving parts of iron or steel, such as shafts (*see* BRASSES). In the construction of electrical apparatus and all kinds of physical instruments, brass plays a very prominent part, and it is used even on very large electrical machinery, as distinguished from electrical apparatus, when a non-magnetic metal is required, as in the case of a "spider"—the structure which connects the core discs with the shaft of an armature.

Brassard, Brassart (*Armour*). The armour which protected the arm, made of metal or leather (*cuir bouilli*).

Brass Bobbins (*Lace Manufac.*) Thin discs of brass that collectively contain one entire system of threads.

Brasses (*Eng.*) The blocks which form the actual bearing surface for a shaft; they are castings fitted into the "plummer block," and are accurately bored to fit the shaft.

—— (*Lace Manufac.*) Thin strips of brass, slightly attenuated or thinned down in the centre, which, when placed together, form sleys or guides that facilitate the working of the steel bars, appliances used in warping.

Brasses, Monumental. From earliest times and in all parts of the world it has been the custom of nations to erect some external sign which should point out the resting-place of their dead; these memorials necessarily assumed various forms. Upon some of them huge sums of money have been lavished, taxing to the utmost the skill of the sculptor, the architect, and the artist; in other cases a simple mound marks the burying place. The ancient Egyptians embalmed their dead, and thus preserved the very bodies of their friends and relatives. In other countries there was still the same strong desire; but instead of trying to preserve

the dead body, a more or less exact representation of the deceased was made in different ways, and these may be conveniently divided into three classes: (1) sculptured effigies; (2) representations engraven or incised on flat plates of brass or slabs of stone; (3) effigies painted on the flat (including glass windows). Though these three classes differ so much in the material used and in the manner of utilising it, yet they one and all have the same general design—*viz.* that of preserving not only the memory, but also the likeness and actual appearance of the deceased. The first of the classes was the most expensive, and consequently confined to persons of rank and wealth. Rarely do we find priests below the rank of abbot commemorated thus, and rarely the ordinary civilian, especially after the introduction of monumental brasses. A monumental brass, also termed "sepulchral brass," and often simply "brass," consists of a flat plate or plates of brass, originally of the mixed metal called *latten*, inlaid on large slabs of stone and representing in their outline, or by lines engraven on them, the figure of the deceased. In some instances, in place of the effigy, a cross was used, and neither name nor escutcheon, nor verse nor encomium is to be found. These memorials were sometimes placed on altar tombs, but more commonly they are to be found on the slabs which form part of the pavement of a church; and it is not improbable that this is another reason why these memorials were so generally adopted, because the area of the church, and especially that of the choir, was not thereby encumbered, as would be the case if sculptured effigies had been used. These brasses vary greatly as regards both size and cost. In Durham Cathedral lies the matrix of a brass to Bishop Beaumont (1333), which measures 16 ft. by 9 ft.; whilst at Cheam, Surrey, the effigy of John Yerde (1449) is only 6¾ in. high. Originally these plates were made in and imported from Germany and the Low Countries. In the early authorities it is termed *Cullen plate*, from which it may be inferred that Cologne (Köln) was the chief emporium. The manufacture of brass was only introduced into England in 1639, when two Germans established works at Esher, Surrey. The Rev. W. E. Hadow thus tersely sums up the advantage of studying these brasses: "Monumental brasses are extremely valuable. The herald, the genealogist, the chronologist, the architect, the artist, the palæographer, and the general antiquary will each and all find much to interest and instruct them in the several branches of knowledge, and they furnish us not only with well-defined ideas of celebrated persons, but make us acquainted with the manners of the times; while to history they give a body and a substance by placing before us those things which language with all its power is deficient in describing." Brasses were first used in England early in the thirteenth century, though the earliest now remaining is at Stoke d'Abernon, Surrey (1277). On the Continent is one at Verden, dated 1231. The brasses graven before the fifteenth century are the best examples of the art. Subsequently the art deteriorated till the eighteenth century, when the use of brasses ceased. Now the art has been revived with good success. The majority of the brasses in England are to be found in the counties situate nearest the Netherlands, and in the counties which were commercially connected with the Low Countries—*e.g.* Gloucestershire. Macklin's *Monumental Brasses* is a very useful handbook. For example of a "brass," *see* ARMOUR.

Brass Finishing. The turning and fitting of small brasswork, such as taps and valves. Usually a special trade distinct from the work of fitters and turners.

Brass Furnace. A small furnace, heated by coke, used in the brass foundry; the metal is usually placed in a crucible, and no blast is used.

Brassica. A genus of plants of the order *Cruciferæ*, including many plants of economic value. *B. nigra* is the black mustard; *B. alba*, the white mustard; *B. oleracea*, the cabbage, with its varieties, cauliflower, broccoli, etc.; *B. campestris*, the turnip; *B. napus*, the rape: yields colza oil.

Brass Moulders. A special class of moulders who rarely work in iron, and generally receive higher wages than iron moulders.

Brass Tube. (1) Common tube is brazed or soldered up from sheet brass; (2) solid drawn (*q.v.*) tubes are used for the most important work—*e.g.* surface condenser tubes.

Brass Winding (*Lace Manufac.*) A term used for brevity, and signifying the process of winding brass bobbins—sixty, eighty, or a hundred at once.

Brattice (*Mining*). A partition (wood or canvas) for separating two air streams in a level.

Brattishing (*Architect.*) Ornamental cresting. *See* CRESTING *and* TUDOR FLOWER.

Braunite (*Min.*) A sesqui-oxide of manganese, Mn_2O_3, brown to black; tetragonal. Ilmenau, in Thuringia, Iblefeld, Piedmont, Elba, etc.

Bravura, Con Bravura (*Music*). With power and brilliancy.

Brayer (*Typog.*) A wooden implement used to rub down and temper printer's ink.

Brazier. A portable fireplace with open bars, commonly used in different forms from times of antiquity.

Brazil Nut. *Bertholletia excelsa* (order, *Lecythidaceæ*). A large South American tree bearing round, hard fruits, containing eighteen to twenty-four seeds—the so-called Brazil nuts of the shops.

Brazilwood. *See* DYES AND DYEING.

Brazing (*Eng.*) The joining of surfaces by means of fused brass or spelter, applied to iron, steel, brass, and other metals, and much stronger than soldering, besides being applicable in many more cases. The joints are cleaned and covered with borax; some of the alloy is then placed over the joint, and heated until it runs in, when it is allowed to set, and any superfluous metal cleaned off. Joints in cycle frames are always brazed, and so neat and strong is a good brazed joint that a broken band saw can be mended by this method without the production of any roughness or projection which would interfere with the action of the saw.

Bread (*Foods*). Bread consists of two classes, the fermented and the unfermented. In the former yeast is used, and in the latter chemical means are adopted for aërating the bread. It should be well baked, not acid, not bitter, and of a good colour. Bread is rich in proteids and starch, but poor in salts and fats. Rice, potatoes, beans, peas, barley, and alum are the usual adulterants. The following gives the methods of manufacture and the chemical results: Flour is mixed with water to form a dough. In this operation gluten, a mixture of nitrogenous substances, is produced. The dough is impregnated with carbon dioxide, either by forcing into it carbon dioxide under pressure (Dr. Dauglish's

system) or by adding yeast. The yeast converts the starch of the flour into maltose and dextrine, and then the maltose into alcohol and carbon dioxide. This gas, hindered from escaping by the gluten, makes the bread lighter. The fermentation and subsequent baking cause several chemical changes in the mixture—*e.g.* the starch is partly changed to more soluble sugars, and it can no longer be separated from the nitrogenous compounds; also, the nature of the nitrogenous matter is changed in some way. Carbon dioxide and alcohol are in part expelled in baking. White bread contains from 7 to 10 parts of proteid, 55 of carbohydrates (starch and sugars), 1 of fat, 2 of salts, and the rest up to 100 parts water. There is on an average in new bread ·3 per cent. of alcohol. Alum, which is often present as an adulterant in bread, serves to whiten it. Experiment has shown that small quantities of alum are not injurious to health. BROWN OR WHOLEMEAL BREAD is made from undressed wheat, and contains the bran as well as the flour. It was formerly considered to be more nutritious than bread made from the finer flour, inasmuch as the bran contains more nitrogenous matter. But it has been pointed out that the nitrogen of cereals exists in two forms—the coagulable and the non-coagulable albuminoids—the former being nutritious, the latter consisting of alkaloids and other compounds containing nitrogen. Bran contains the latter, which is comparatively useless, whereas in fine flour the nitrogen is found in the first condition. An argument against the use of brown bread is that the cellulose in the bran acts as an irritant, stimulating peristaltic movement (*q.v.*) The excess of cellulose also cannot be digested, and is said to interfere with the absorption of digestible foods. *See* BAKEHOUSES.

Breadth (*Lace Manufac.*) Any width of lace less than a "web" that is complete in itself.

—— (*Paint.*) Is thus defined by Ruskin: "Good composers are always associating their colours in great groups . . . and securing . . . what they call 'breadth'—*i.e.* a large gathering of each kind of thing into one place, light being gathered to light, darkness to darkness, and colour to colour."

Breakdown Crane (*Eng.*) An accident crane. *See* CRANES.

Breaker. A machine used in paper manufacture for disintegrating rags into "half stuff."

Breaking (*Foundry*). A striated appearance on the surface of melted iron; the quality of the iron can be judged to a certain extent by the appearance of these striations.

Breaking Joints (*Build., etc.*) The prevention of two or more successive joints from coming into line. This is done to increase the strength of the structure. The BOND (*q.v.*) in masonry is an example; the arrangement of the joints of piston rings (*q.v.*) is another.

Breaking Pieces (*Eng.*) Short shafts by which power is transmitted to the rolls of a rolling mill. They are made weaker than the axles of the rolls, so that if the mill is overstrained they will break first, and prevent a fracture of the rolls or their axles.

Breaking Strength. The force or load necessary to break a piece of material of specified size.

Break Lathe (*Eng.*) A large lathe whose bed can be disconnected from the head stock so that it can be moved farther away, to suit larger work.

Breaks in the Succession of Strata (*Geol.*) These mean nearly the same thing as "unconformity"; but it is sometimes convenient to employ the present expression in cases where rocks are absent which are known to occur elsewhere, but where there is no visible discordance between the two rocks which succeed each other in the same section. A further distinction is made in the case of any marked hiatus between the organic remains of two apparently conformable sets of rocks, in which case the term PALÆONTOLOGICAL BREAK is used.

Breakwater (*Marine Eng.*) A bank or wall of masonry used to protect a harbour, etc.

Breast (*Build.*) The part of a wall projecting into a room and containing the flues.

—— (*Mining*). The face or working surface in a level.

Breast Beam (*Cotton Weaving*). The front cross-rail of loom over which the cloth passes to the cloth roller.

Breast Hole (*Met.*) In a cupola, the door or opening just above the base for lighting the fire and extracting the cinders and slag.

Breastplate (*Arm., etc.*) Armour which protected the breast. A large metal ornament worn on the breast.

Breast Wheel (*Eng.*) A water wheel which turns in a quadrant-shaped bed, so that the water strikes the floats at the level of the axle, and remains in contact with them till the lowest point of the wheel is nearly reached.

Breccia (*Geol.*) A compacted aggregate of fragments of stone which are angular instead of being rounded, as they are in a conglomerate. The angularity of the constituents serves to indicate that the stones have not been exposed to the rounding action to which running water gives rise, and the feature in question may thus become one of some importance in relation to the history of the rocks of which a breccia forms a part.

Breeches Pipe (*Eng.*) A ⅄-shaped pipe in a locomotive which receives the steam from the two cylinders and discharges it into the chimney, in order to force the draught.

Breeze. A name given to various kinds of fuel in a fine state of division. Thus coke breeze is finely divided coke. In brickmaking, sifted coal cinders are extensively used, both for mixing with the loam before moulding into bricks and for putting between the layers in a clamp when the bricks are burnt in that way.

—— (*Build.*) Fine cinders used with cement to make concrete.

Breguet Spring (*Watchmaking*). A flat spiral balance spring with its outer coil bent up into a horizontal plane parallel with the body of the spring, and then curved in towards the centre and fixed to the stud between the outer coil and axis of balance. This spring, which is only found in better class watches, secures less variation in timekeeping when the position of a watch is altered by the movement of the wearer or otherwise.

Bressummer (*Build.*) A beam carrying a wall, as a girder over a shop front.

Bretessé (*Her.*) An ordinary with edges embattled; also called CRENELLÉ.

Breve (*Music*). *See* NOTE.

Brevier (*Typog.*) Type one size smaller than bourgeois and one size larger than minion. *See* TYPE.

Briar Root. *See* WOODS.

Bric-a-Brac. Antique curiosities of artistic character: furniture, china, plate, fans, statuettes, etc.

Brick Arch (*Eng.*) In locomotives, an arch of firebrick placed in front of the openings of the tubes to deflect the flame backward.

Brick Earth (*Geol.*) Any loam or native mixture of clay with sand which serves for the manufacture of bricks. In the south-east of England, and especially in the Thames Valley, it is usually restricted to a kind of buff or ochreous loam which has been left as a sedimentary deposit on the sides of the valley. By many it is regarded as a form of alluvium; others think it represents a deposit formed at a time when the river was ponded back into a lake by an ice barrier across its mouth at the climax of the Age of Snow.

Bricking Up (*Foundry*). In moulding, the formation of part of a large mould with bricks instead of using sand alone.

Bricknogged (*Build.*) A brick partition with horizontal NOGGING PIECES (*q.v.*) to tie it together.

Bricknogged Partition (*Build.*) A partition built of bricks and mortar. with nogging pieces (*q.v.*) about every 3 ft. of its height to bond it together.

Bricks (*Brick Earths*). The clay from which bricks are formed varies considerably in composition. The following are examples: *Reddish-Brown Clay:* Silica, 53; alumina, 31; water, etc., 9; iron oxide and lime, 3·5; magnesia, 2·5. *Red Brick Clay:* Silica, 50; alumina, 24; water, etc., 22; iron and lime, 2·7; magnesia, 1·3. *A Common Marl Clay:* Silica, 33; alumina, 11; water, etc., 10; lime, etc., 40; magnesia, 6. *A Sandy Clay:* Silica, 60; alumina, 24; water, 12; lime, etc., 2·4; magnesia, 1·6. It will be instructive to compare these with the analysis of very pure clay, such as china clay: Silica, 45; alumina, 45; water, 8; iron oxide and lime, 2. The commonest bricks are made from a marly or a sandy clay, the latter being often termed "loam." An artificial imitation of marl, termed "malm," is produced by mixing clay and chalk with water in a puddling mill.—MANUFACTURE: The first operation is the removal of the surface earth, which is termed "unsoiling." The clay is then cut out, broken into small pieces by the spade, and exposed for a considerable time to the air, in order to become "weathered." It is then cleared of stones, either by hand picking or, on a larger scale, by washing in a mill, from which the clay, mixed with water to a creamy consistency, is allowed to flow into a WASH BACK, where it is left to dry in the air until it attains the requisite consistency. It is then cut out in blocks, ground with breeze in the PUG MILL, and then is moulded into the shape of bricks by hand labour or by a brick-making machine. The next process is extremely important: it consists of drying the bricks in air. They are stacked in long rows on raised platforms of earth known as HACKS, and are arranged in such a manner as to leave numerous air spaces between them. They are protected from the rain by a loose roof of straw, or sometimes by light screens made of reeds, or else by a simple form of roof, and are left until the whole of the visible moisture has evaporated. The bricks are then termed "green bricks." When sufficiently dried, the green bricks are ready to be burned. There are two principal ways of carrying out this operation. In the older method, the bricks themselves are built up into a kind of hollow chamber, with flues running through it, termed a CLAMP. A fire is kept burning inside this until the whole of the bricks have been sufficiently burned. Those close to the flues are in most cases seriously overburnt, and are termed "burrs." Those which are less overburnt are termed "hard stock," and are useful for many building purposes. The outermost bricks of the clamp are frequently left underburnt, and are useless for all ordinary work. A more modern process is to use a permanent kiln for burning; and in this case it is much easier to attain uniformity in the process, and also to regulate the burning to any desired degree.—VARIETIES OF BRICKS: (1) *Cutters or Rubbers:* A fine-grained brick, commonly red, which is suitable for working to any definite shape, for arches, mouldings, etc. Malm bricks are often used for the purpose; and two of the best varieties of cutters are Fareham reds—a deep red brick made from the Fareham clay; and Lawrence's cutters, made from a brick earth at Bracknell, which is carefully strained and washed. (2) *Dutch Bricks:* A light-coloured hard brick suitable for paving and similar work. (3) *Gault Bricks* or "*Gaults*": Bricks made from the blue clay termed by geologists "gault"; frequently made with holes to serve as air bricks or ventilating bricks. (4) *Leicester Reds:* A heavy brick which has been subject to pressure in its formation. (5) *Malm Builders:* Kiln-burnt bricks, from specially prepared malm. (6) *Red Builders:* Used for good building work; made from washed earth. (7) *Rubbers:* Another name for cutters (*q.v.*) (8) *Shippers:* The last selected stock or ordinary bricks, so called from being originally those which were selected for shipment. (9) *Stafford Blues:* Very heavy hard brick, containing a high percentage of iron (10 per cent.), and extremely durable. (10) *Stocks:* Also termed "grey stocks," or London stocks, a general name for the ordinary clamp-burnt bricks of the better kind. (11) *Suffolks:* Cream-coloured bricks made from marl; used for facework. In addition to the above, moulded bricks are used for arches, quoins, plinths, string courses, and other ornamental work. Those used for arches are often called "arch bricks" and "gauged bricks." Other bricks are finished with a polished surface, sometimes by ordinary glazing with salt, and at others by a more elaborate glaze similar to that used for earthenware. These are used for ornamental work, for reflecting light, or for sanitary purposes. —FIREBRICKS: Firebricks are used for the interiors of flues and furnaces. They must be infusible at the temperature to which they will be exposed; they must also be free from cracking at this temperature, and must retain their shape and size, as any alteration in this point would probably destroy the whole interior of the furnace, causing the roof and arches to give way. In other cases, firebricks have to resist the destructive action of the fluid metals and slags produced in the furnace. The requirements of a good firebrick, therefore, vary considerably, but in nearly all cases are exacting and difficult to meet. Only special clays, termed "fireclays," can be used. An example of fireclay is as follows:—Silica, 50; alumina, 30; water, etc., 12; iron oxide, 4; lime, 2; magnesia, 2. The chief points in which this differs from an ordinary brick earth are the comparatively high per-

centages of alumina and iron oxide and the absence of any free alkalis. These characteristics contribute very largely to the infusible character of the brick. The presence of alumina in large quantities is not, however, essential in all cases, as a very good form of firebrick is made from Kieselguhr, which is a highly silicious earth, originally produced by minute organisms called "diatoms." The composition of Kieselguhr is typically: Silica, 84; alumina, 1; water, 7; iron oxide, 2; lime, ·8; magnesia, ·7; organic matter, 4·5. In burning these Kieselguhr bricks the iron appears to act as a flux—*i.e.* helps to form a fluid substance, which, when it solidifies, cements the remaining material together. These bricks are very light, but very durable, and are much used for firebricks in chemical works.

Bridge (*Eng.*) (1) An arch or series of arches of brick, stone, or cast iron; (2) a platform carried on wrought iron or steel girders, either supported on piers of masonry or metal, or hung by chains from lofty piers at each extremity of the bridge; (3) applied to various parts of mechanism or structures which have some resemblance to an ordinary bridge; (4) a barrier placed across a furnace to deflect the flames and hot gases. *See also* ARCH.

—— (*Music*). The piece of wood on which the strings of musical instruments are stretched.

Bridge, Wheatstone (*Elect.*) *See* WHEATSTONE'S BRIDGE.

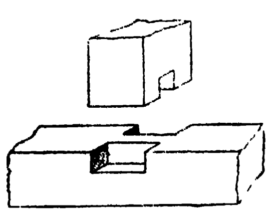
Bridging Joist (*Carp.*) The timbers to which the floor boards are nailed.

Bridle (*Eng.*) The loop by which a slide valve is connected to the valve rod.

—— (*Dec.*) The method of tying up a painter's brush when it is new and the bristles are too long for use. Whipcord is wound around the bristles from the binding, and is secured by being tied to the handle or to pieces of copper wire bound in with the bristles for the purpose. Various ready made bridles are also used.

Bridle Butts *or* **Backs** (*Leather Manufac.*) Butts (*q.v.*) tanned for bridle and harness work; must be pliable, free from blemish, and of good colour.

Bridle Joint (*Carp.*) A joint of the form shown. Used in place of a mortice and tenon.



BRIDLE JOINT.

Brigandine Armour. Armour consisting of canvas or leather, quilted with small thin pieces of iron; worn by mediæval archers and crossbowmen.

Bright Red Heat. A temperature ranging from 1700° to 1800° F.

Bright Work. Surfaces which have been machined or merely polished by the file, emery, etc.

Brill (*Zool.*) *Rhombus lævis* (family, *Pleuronectidæ*). A flat-fish allied to the turbot, but inferior to the turbot as food.

Brillante (*Music*). Brilliant.

Brilliant (*Min.*) A term used for a special form of cut diamond. *See* DIAMOND *and* PRECIOUS STONES.

—— (*Typog.*) Type a size smaller than diamond, and practically the smallest used. *See* TYPE.

Brimstone. A common name for artificially prepared sulphur. *See* SULPHUR.

Brinded *or* **Brindled** (*Her.*) Said of animals covered with spots or streaks of colour.

Brine Pump (*Eng.*) *See* SALTING.

Brin's Process. A method of obtaining oxygen from the air on a large scale. Air is freed from moisture and carbon dioxide, and passed under a pressure of about two atmospheres over barium monoxide, BaO, heated to a constant temperature of 700°. Under these conditions BARIUM DIOXIDE, BaO_2, is formed. The residual nitrogen is allowed to escape; then the pressure is reduced to a few inches of mercury, and the dioxide gives up oxygen, which is collected; the monoxide remains, and is used again.

Brio (*Paint.*) Painted with spirit or "go."

Bristled (*Her.*) When the bristles of a boar are of a different tincture from the body.

Bristles. The coarse stiff hairs obtained from the pig and used in brushmaking. They are imported chiefly from Russia.

Bristol Board. A fine kind of pasteboard or cardboard with a smooth or glazed surface; used for pen-and-ink drawings, watercolour drawings, and mounts.

Bristol Porcelain. Pottery of the nature of Delft was made in Bristol as early as the close of the seventeenth century. A manufactory of porcelain was established in 1768 by Champion, who in 1774 took over Cookworthy's patent for the manufacture of hard-paste. There is no record of this porcelain having been made after 1777. Two other manufactories were established for the manufacture of earthenware, one of which (Pountney's) is still in existence. For Porcelain Marks, *see under* POTTERY.

Britannia Metal. A white alloy of tin and antimony, usually also containing small amounts of copper and zinc; a typical specimen contained: Tin, 86; antimony, 10; copper, 1; and zinc, 3 per cent.

Britch (*Woollen Manufac.*) The fibre from the extremity of the tail end of fleece.

British Gum. This is not a true gum. It is prepared by carefully heating starch, when a product containing dextrine or substances allied to it is obtained.

British School of Painting. *See* PAINTING, SCHOOLS OF.

Brittle Silver Ore (*Min.*) A synonym for STEPHANITE (*q.v.*)

Broach (*Architect.*) A spire, generally used to denote that kind of spire which rises from a tower without any parapet, as is usual in Early English architecture.

—— (*Eng.*) A tool for enlarging and finishing off round holes which have been drilled or punched.

—— (*Woollen Manufac.*) A wooden spindle on which the cops of yarn are fixed for warping, etc.

Broadcloth (*Woollen Manufac.*) Fine, plain-wove black cloth, dressed. Used principally for men's clothing.

Broad Gauge (*Eng.*) Railway lines set 7 ft. apart; now abandoned. *See* NARROW GAUGE.

Broadside. A sheet of paper printed on one side only, the matter generally being of a popular character.

Brob (*Eng., etc.*) A large spike used to fix heavy timber work.

Brocade (*Cotton Weaving*). A class of figured weaving produced by means of the "Jacquard," in which the warp and weft are made to float indiscriminately on the surface of cloth to form a desired pattern or figure, the ground weave being of a firm structure. The figures are principally weft.

—— (*Silk Manufac.*) A term now applied to most figured silken fabrics; originally it was used to denote only those silks where the figure consisted of various-coloured wefts and metal threads woven into the cloth by means of small shuttles, which were passed under the warp threads in such places as the figure occurred, instead of being thrown across the entire width of the work.

Brocatel *or* **Brocatello.** A variegated species of marble, obtained principally from different parts of Italy.

Brocatelle (*Silk Manufac.*) A thick figured silk used for upholstery purposes, made with an extra weft of linen yarn, which causes the satin figure to have a raised or plump appearance.

Broché. Fabric enriched with figures or design in relief.

Broken Entablature (*Architect.*) An entablature which does not project uniformly from the face of the wall, but has an increased projection over each column or pilaster. *See also* ENTABLATURE.

Broken Glass (*Met.*) Used to cover the surface of molten brass to check oxidation.

Broken Over (*Bind.*) Used in respect of plates when a fold has been made a short distance from their back edge before they are fixed in a volume.

Brokes (*Woollen Manufac.*) Short locks of wool removed from the edges of the fleece, grown on the neck and belly.

Bromates. Salts of bromic acid. POTASSIUM BROMATE, $KBrO_3$, is made by adding bromine to caustic potash: $6KOH + 3Br_2 = 5KBr + KBrO_3 + 3H_2O$. The bromate, being much less soluble than the bromide, is separated by crystallisation. Bromates on heating decompose, giving oxygen and a bromide.

Bromic Acid, $HBrO_3$. Forms a strongly acid liquid; it is a powerful oxidising agent; hence it bleaches. It may be obtained by passing chlorine into bromine water or by acting upon silver bromate (prepared by adding silver nitrate to potassium bromate) with water and bromine.

Bromide Emulsion (*Photo.*) A solution of gelatine containing silver nitrate and potassium iodide and bromide. A good formula is: Gelatine, 280; $AgNO_3$, 175; KBr, 135; KI, 5 parts by weight.

Bromide Prints. Prints on paper, porcelain, etc., which has been coated with a gelatine emulsion containing silver bromide, very similar to that used on dry plates. The prints are developed and fixed like dry plates.

Bromides. Salts of hydrobromic acid (HBr). *See also under* POTASSIUM *and* SILVER.

Bromine, Br. Atomic weight, 80. A dark red heavy liquid (sp. gr. 3), boiling at 59°; it has a powerful and irritating smell, and the vapour attacks the eyes. Unites directly with many elements to form bromides (union with potassium and phosphorus is explosive). Soluble in carbon disulphide and in acetic acid; also sparingly soluble in water, the solution decomposing in light. Acts on many organic compounds, forming either substitution products—*e.g.* C_6H_6 (benzene) gives C_6H_5Br (monobrombenzene) or addition products—*e.g.* C_2H_4 (ethylene) gives $C_2H_4Br_2$ (ethylene dibromide). Prepared on large scale by heating the mother liquor obtained in the preparation of potassium chloride from Carnallite by means of steam, and passing chlorine into it. The chlorine liberates bromine from the magnesium bromide, and the escaping bromine is condensed. On small scale it is produced when a bromide is distilled with manganese dioxide and sulphuric acid. Resembles chlorine in its chemical behaviour; thus it bleaches, and acts upon alkalis like chlorine (*q.v.*)

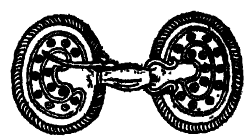
Bromo Compounds. These are formed from organic compounds by replacement of one or more hydrogen atoms, directly or indirectly, by one or more bromine atoms. Thus tribromophenol is phenol (C_6H_5OH), in which three hydrogen atoms have been replaced by three bromine atoms, giving $C_6H_2Br_3OH$, in which the bromine atoms occupy the positions 2:4:6 in the benzene ring (*see* BENZENE), the OH group being in position 1.

Bronchi (*Zool.*) The two tubes formed by the division of the trachea or windpipe. They again divide, and their branches pass into the lungs, where they ramify.

Bronze. An alloy of copper, tin, and zinc in somewhat variable proportions. The British coinage is composed of 95 parts of copper, 4 of tin, and 1 of zinc. Ancient bronzes contain only copper and tin. *See also* GUNMETAL.

Bronze Age (*Geol.*) The prehistoric period when men employed instruments of bronze in war, in the chase, and largely for domestic purposes. It followed the Neolithic Age, when smoothed stone instruments were used, and it preceded the period when iron began to come into general use. Both its commencement and its termination are indefinite, and they varied in different countries according to local circumstances.

Brooch (*Cost.*) An ornament or clasp to which a pin is attached, now used chiefly for fastening some portion of female wearing apparel, generally on the breast, but formerly often worn by men also, frequently on the hat or cap.



It is still one of the indispensable ornaments of a Highland costume. The illustration is from a Danish brooch of the later Bronze age.

Brookite (*Min.*) TITANIC OXIDE, TiO_2. Rhombic. It often occurs in brown capillary crystals. Two of the chief localities are Cornwall and Dauphiny.

Brought Forward (*Dec.*) This term signifies that all work to be painted is ready for the finishing coat at the same time.

Brown (*Paint.*) A composite colour produced by mixing orange and black, or red, black, and yellow. Great variation in shade can be obtained according to the proportion of the constituents.

Brown Bear (*Zool.*) *Ursus arctos* (family, *Ursidæ*). The Brown Bear is valued for the sake of its fur and flesh (hams and paws) and fat.

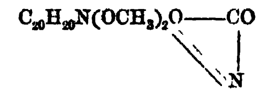
Brown, Bismarck. *See* DYES AND DYEING.

Brown Coal (*Geol.*) A stratified deposit of fossil matter of vegetable origin which has undergone a

certain amount of change within the strata enclosing it, but which change has not proceeded sufficiently far to convert the substance into true coal. The percentage of carbon present is usually between 65 and 80, and of oxygen between 25 and 15. It is often associated with strata of fresh water origin. It is an important source of fuel in connection with some of the Tertiary rocks of the Continent. *See also* COAL.

Brown Hæmatite (*Min.*) A synonym for Limonite (*q.v.*)

Brucine.



An alkaloid occurring along with strychnine in nux vomica. Forms colourless prismatic crystals or pearly flakes; melts at 178°. Physiological action similar to strychnine, but 38½ times less powerful. It is more soluble in water and in alcohol than strychnine. It is lævorotatory; a tertiary base; and although it contains two nitrogen atoms, it is a monacid base. With nitric acid it gives a red colour even in very dilute solutions; the colour changes to violet on adding stannous chloride. This forms a very delicate test either for brucine or nitric acid.

Brucite (*Min.*) Native magnesium hydrate; it occurs in tabular hexagonal prisms with a perfect basal cleavage. Thin laminæ are flexible, but not elastic. Composition: $M_g(OH)_2$, magnesia = 68·97, water = 31·03 per cent. When heated before the blowpipe it does not fuse, but becomes brilliantly incandescent. It occurs at Swinna Ness in the Shetland Isles, and at several localities in the United States.

Brunswick Black. A quick-drying black varnish made from asphaltum and used principally for coating iron.

Brunswick Green (*Paint.*) A pigment used in oil painting, manufactured from carbonate of copper and chalk or lime. In trade work, a useful series of greens is made, in four or five shades, from chrome yellow and Prussian blue, on a base of barytes. They are apt to fade, but may safely be mixed with other pigments excepting those which contain sulphur. Brunswick greens are inferior in quality to chrome green.

Brushes (*Dec.*) *See* PAINTER'S BRUSHES.

—— (*Elect. Eng.*) Strips of copper, either solid or built up of gauze, or else rods of carbon, which convey the current from the terminals of an electric motor to the commutator or in the reverse direction in the case of a dynamo. By means of "rocking frames" or holders the brushes can be moved round the commutator until the best position (that where least sparking occurs) is obtained. This adjustment has to be made with great care, or loss of energy and injury to the machine will result.

Brush Holder (*Elect. Eng.*) The support or frame carrying the copper (or carbon) strips by which the current enters or leaves a motor or dynamo. The brush holders are carried by a "rocking frame" which enables the point of contact of the brushes with the commutator to be varied at will.

Brushwork (*Paint.*) (1) A term used by artists to signify the manner in which the pigments are laid upon canvas in oil painting and upon paper in water-colour work. Every painter has his particular method of handling his materials, and the quality of his brushwork is one of the most important factors in the expression of his individuality. (2) A method of teaching drawing and design by means of water-colour drawing, chiefly in vogue in elementary schools. The painting is executed by means of the brush alone, no outline of the subject being previously made.

Brussels Lace, *also called* **Point d'Angleterre.** Perhaps the most representative of all laces either for quality or beauty of design, which changes with the fashion and always keeps up to date. It was first made in the fifteenth century, and about 1626 the city of Brussels had attained such proficiency in the manufacture as to be the envy of the whole of the surrounding districts. England also becoming alarmed at the enormous sums paid to the foreigner, introduced certain fiscal changes, with the idea of stopping its importation and at the same time fostering the English lace industry. The merchants brought skilled lacemakers to this country, and attempted to introduce the manufacture; but as the British workmen had not attained proficiency in the production of the thread, the result was failure. The name was then changed to Point d'Angleterre, and smuggling was resorted to, which seems to have been quite a success. Nearly every known stitch or method may be embodied in Brussels lace, as the principle of manufacture lends itself to distinctive treatment, and the various objects and fillings and different varieties of ground are made separately, each by the worker most skilled in her particular department, and afterwards combined.

W. H.

Bubble Tube. The glass tube of a level containing spirit. It encloses a bubble of air.

Bucentaur. A mythical creation half man, half ox. Also the name of the State barge or galley of Venice in which the Doge and Senate performed the ceremony of wedding the Adriatic.

Bucket (*Eng.*) (1) The scoop used with various forms of dredgers; (2) The piston of a suction pump; (3) The receptacle which catches the water in water wheels.

Bucket Ladder Dredger (*Civil Eng.*) A continuous chain driven by machinery carries a number of sharp-edged buckets, which scoop up the material and raise it above water level, where it is discharged into suitable barges. The chain works over wheels at the top and bottom of a frame in such manner that the buckets at the lowest part of the chain touch the bottom of the channel.

Bucket Valve (*Eng.*) The valve in the piston of a common suction pump.

Buckle (*Architect.*) *See* MASK.

—— (*Cost.*) An instrument, often ornate, consisting of a rim of metal with a chape and tongue. Used for fastening straps or belts.

—— (*Eng.*) The curving of a flat plate caused by stresses set up from contraction and other causes: a permanent "set" or twist in a piece of material which should be flat.

Buckled Plates (*Eng.*) Plates to which a dish-like curve has been given; used in some forms of bridge construction, as the plate has greater stiffness than a flat one.

Buckram. A strong coarse form of linen material of plain texture, highly finished. Used for linings and for binding books likely to be much handled.

Buckskin (*Woollen Manufac.*) Fine twilled woollen cloth, with the weave or twill lines clearly defined.

Buckskin Leather. Originally made from buckskins, dressed by oil dressing; now made from any kind of deer. Frequently made from sheep, calf, and horse hides.

Buckwheat. *Fagopyrum esculentum* (order, *Polygonaceæ*). The fruits of this member of the dock family constitute a much used food in some European countries and in America.

Buddle (*Mining*). A machine for washing ore by rotating it in a circular vessel or pool of water.

Buff (*Colour*). A light yellow.

—— (*Eng., etc.*) A wheel covered with leather, on which fine emery, etc., is placed for polishing metallic objects.

Buff Coat. A military outer garment made of skin or other thick and elastic material. The sleeves were short, and the garment was laced across the chest. Worn by soldiers during the seventeenth century.

Buffer (*Eng.*) A stop intended to check a heavy shock by causing the gradual compression of a spring or its equivalent.

Buffing (*Leather Manufac.*) A process by which the grain surface of the leather is removed: formerly done by hand with a buffing knife; now largely done by machine.

Buff Leather. Leather from which the upper surface or "grain" has been "buffed" off (removed). Chiefly used for Army work. Dressed with oil.

Bugle. *See* MUSICAL INSTRUMENTS: WIND, BRASS.

Bugle Horn (*Her.*) A small hunting horn. When blazoned, it should state if the shoulder strap is shown; if so, the bugle is *enguiché*.

Buhl (*Furn.*) A kind of furniture manufactured by Boule (1642—1732), an Italian wood carver, who introduced this style in France during the reign of Louis XIV. Unburnished gold, brass, mother of pearl, tortoiseshell, etc., worked in complicated patterns were used for inlaying. Buhl is a German form of the name.

Building Motion (*Cotton Spinning*). For building up the layers of roving on the bobbins of a fly frame so as to lay them uniformly, and also give a tapered shape at the top and bottom; sometimes termed "box of tricks." Occasionally used in respect of the building of a cop on a mule.

Building Stones. The qualities requisite in stones suitable for building work are very various, and depend on the nature of the work. Strength and durability are usually the two most important qualities; but the exact nature of these will depend on whether the stone is to be exposed to the outer air or to be under water, or only to be used in the interior of the building. Ease of working depends upon the softness or hardness of the stone: a very hard stone might be extremely difficult to work, both in the quarry and on the bench; while a very soft one may break away under the tools, and therefore be useless. For ordinary building purposes limestone and sandstone in some form are the stones most used. The former is always liable to be attacked by the atmosphere to a considerable extent, as rain water, containing a certain amount of carbonic acid in solution, can dissolve away carbonate of lime, which is the chief constituent of a limestone. Sandstones, being composed largely of silica in a form of minute grains of quartz, are not liable to these destructive actions, and their durability will depend almost entirely on the strength of the natural cementing material by which the grains of quartz are held together in the stone. Granite and rocks of its class are the most durable of all stones; but they are difficult to work with ordinary mason's tools, and as they occur in huge masses in the earth, instead of being in layers or "stratified," as limestones and sandstones are, the expense of quarrying them is also very much greater. For these reasons granite and similar rocks are only used in the very heaviest work where enormous strength is absolutely necessary, or else in decorative work where the high cost is not an obstacle. Marbles and similar rocks are as a rule only suited for internal work where they will not be subject to much wear and tear. The classification of building stones is a somewhat difficult matter. The geologist would classify them according to the manner in which they have been formed, dividing them into three classes—the aqueous rocks, which have been formed by the action of water—*e.g.* limestones and sandstones; the igneous rocks, which have solidified from a fluid condition, and include granite, syenite, basalt, and similar rocks; and metamorphic rocks, which are rocks originally belonging to either of the above classes, afterwards modified by the action of heat or intense pressure. For building purposes it is more convenient to classify all rocks in accordance with the uses to which they are put. This gives us the following classification of stones used in: I. ORDINARY MASONRY WORK: (**A**) Limestones. (**B**) Sandstones, and occasionally certain other rocks. II. HEAVY MASONRY AND ENGINEERING: Stones used in the foundations of heavy buildings, piers, breakwaters, and engineering work generally; various forms of granite, syenite, etc. III. PURELY ORNAMENTAL WORK: Marbles, serpentine, granites, syenites, etc. It will be seen that there is a certain amount of overlapping in the above classification, which it is impossible to avoid, as many of the stones which are most useful for the heaviest work are also extensively used for purely decorative purposes. I. (**A**) The principal limestones in actual use are as follows: (1) *Ancaster Stone* and "*Oolite*" *Limestone:* From Lincoln, used for general building work in the locality, and for doors, windows, etc., elsewhere. (2) *Bath Stone*, "*Great Oolite*" *Limestone*. Found in the Somerset hills, at Box, Chippenham, Doulting, etc. This stone is soft when first quarried, but gradually hardens in air. It is slightly shelly, but fine grained; very extensively used for general building work, and also for external decorative work, as it is extremely suitable for cutting and moulding. Examples: Bath Abbey, Glastonbury Abbey (eleventh century), Wells Cathedral (twelfth and fifteenth centuries), and many collegiate buildings in Oxford from the Twelfth to Fifteenth centuries. All these buildings are in a good state of repair, putting the durability of the stone beyond dispute. (3) *Bolsover Stone*, "*Magnesian Limestone*," or "*Dolomite*": Composition (percentage): calcium carbonate, 51·1; magnesium carbonate, 40·2; iron and aluminium oxides, 1·8; silica, 3·6; water, etc., 3·3. Easily worked stone, not very durable. (4) *Caen Stone:* From the "Jurassic" rocks of Normandy. Very fine stone for decorative work, much used on the Continent and in many buildings in this country; not as durable as many other building stones. (5) *Doulting Stone:* A variety of Bath stone. (6) *Ham Hill Stone:* A variety of Bath stone. (7) *Headington*

Stone: A soft limestone from Oxfordshire. It has been used in the restoration of many Oxford buildings; but it is easily seen, on inspection, that the stone is not very durable, as the restored work shows many signs of decay. (8) *Huddlestone Stone:* A limestone quarried at Park Nook and other places in Yorkshire. (9) *Portland Stone:* A limestone from the upper Jurassic rocks of the Isle of Portland, near Weymouth. Superior to the oolitic limestones in hardness and durability, but less adapted to delicate chiselling. Colour, white to light brown; stands the weather well. This stone has been much used for many years. St. Paul's Cathedral is a fine example; also the Goldsmiths' Hall, and the Customs House, built 1817. Another good example which should be inspected by students of building materials is the fine statue, a copy of the "Farnese Hercules," in the Museum of Practical Geology. (10) *Mansfield Stone:* A durable arenaceous limestone of light colour, used in the lower parts and foundations of the Houses of Parliament; also extensively used for paving. (B) Sandstones used in general building. (1) *Belton Stone:* A sandstone from the "Lower Keuper" rocks of Shropshire; white and light red. (2) *Branley Stone:* Coarse-grained sandstone from the "Millstone Grit" of Yorkshire; very durable; suitable for general building, paving, stone steps, and also heavy work, such as foundations for machinery, piers, and bridges. (3) *Craigleith Stone:* A whitish-grey sandstone; very durable; used for general building, especially Ashlar work, steps, and landings. Much of the older part of the city of Edinburgh is built of this stone. Quarried at Craigleith, on the north-west side of the city. (4) *Darley Dale Stone:* From Derbyshire. A yellowish-brown sandstone of fine grain, containing flakes of mica. Darley Abbey and Birmingham Grammar School are built of this stone. (5) *Dumfries Sandstone:* A bright red sandstone, locally used, but not very durable. (6) *Dundee Sandstone (Arbroath Flags):* From the "Old Red Sandstone." Splits into large and flat "flags," and is much used for paving, as it is hard and durable and very impervious to moisture. (7) *Elland Sandstone:* From the Millstone Grit of Yorkshire. A fine greyish-brown micaceous stone, used for paving. (8) *Harrock Hill Sandstone:* A coarse-grained stone, used for paving, heavy foundations, engine bases, etc. (9) *Heddon Stone:* From the "Carboniferous Limestone Series," near Newcastle. A light brown stone, sometimes containing fine layers (or "laminæ") of black carbonaceous matter. Used locally and also elsewhere for the facings of buildings. Many examples of its use are found in Edinburgh. (10) *Hollington Stone:* A fine-grained sandstone, white to grey in colour, from Uttoxeter; used in many large buildings in the Midlands—*e.g.* Drayton Manor and Derby Town Hall. (11) *Kentish Rag:* A sandstone of calcareous nature (*i.e.* containing a certain amount of carbonate of lime), from the "Lower Greensand" group of rocks. A light brown or grey stone; fine, shelly, not very hard or durable; extensively used in many buildings of modern date in the south-east of England. Quarried at Godstone, Maidstone, Folkestone, etc. (12) *Longridge Stone:* from the "Yoredale Rocks" of Longridge Fell in Lancashire. A durable sandstone; used in the north of England—*e.g.* Preston Town Hall. (13) *Manley Stone:* A sandstone found in Cheshire; colour varies from white to red; used in the restoration of Chester Cathedral. (14) *Penistone Sandstone:* Yorkshire. Used for flagstones. (15) *Penrith Sandstone:* A bright red sandstone from the "Permian" rocks. In many ways a good building stone; used throughout the town of Penrith and neighbourhood, and sometimes elsewhere, on account of its fine colour and appearance. It is not, however, very durable, as the dilapidated state of the old castles of Penrith and Brougham in the neighbourhood clearly show. (16) *St. Bees' Stone:* Similar to the Penrith Sandstone in colour, durability, etc. (17) *Stancliffe Stone:* Similar to the Darley Dale stone (*q.v.*) (18) *Wheatwood Stone:* A sandstone from Yorkshire, varying from a very fine grain to a coarse grit; durable. Examples: Whitby Abbey and the new University Library at Cambridge.—II. STONES USED IN HEAVY MASONRY. (1) *Aberdeen Granite:* A grey granite, extremely hard and durable. Practically the whole city of Aberdeen is built of this stone, and it is also much used elsewhere, both for heavy work and also for ornamental work, on account of its fine appearance when polished. (2) *Cornish Granite:* One of the finest varieties of granite for heavy work. Examples of this are found at Portland Breakwater, Keyham Dock, Commercial Docks (London), the London Docks, and Waterloo Bridge. From the granite found at Cheesewring, Westminster Bridge and the Thames Embankment are built. (3) *Dartmoor Granite:* A greyish granite used in large work—*e.g.* London Bridge. (4) *Mount Sorel Granite:* From Leicestershire. A very hard granite, difficult to quarry, and therefore expensive. Much admired for its warm rose tint, and therefore used in ornamental work, as well as in work requiring great durability, such as paving. (5) *Peterhead Granite:* Fine red granite of very close texture. It can be obtained in very large blocks, and is therefore suitable for columns. A good example of the latter can be seen in the columns of the Carlton House Club in London, and students should also inspect a large vase of the same stone in the vestibule of the Museum of Practical Geology. (6) *Shap Granite:* A very fine granite, with large crystals of red felspar. This stone is regularly worked for ornamental purposes, and takes a very high polish. (7) *Syenite:* This is an igneous rock very similar to granite, from which it is distinguished by the fact that little or no free quartz is found in it. Mount Sorel in Leicestershire is one of the best known English quarries. A fine syenite from Norway, whose colour varies from grey to dark green; is very much used in England for panels and decorative work, especially in the fronts of many modern hotels. This syenite contains large crystals of iridescent felspar, and its appearance when polished is extremely fine; the crystals of felspar reflect the light to a very considerable distance. (8) *Porphyry:* An igneous rock containing large crystals, chiefly used for ornamental purposes. An English example is known as Luxullianite, from Luxullian, in Cornwall. This stone is used in the sarcophagus of the Duke of Wellington at St. Paul's Cathedral. A more celebrated porphyry is the Egyptian one quarried near the first cataract of the Nile, and much used in ancient work in Egypt. (9) *Basalt:* A dark-coloured, heavy, and close-grained eruptive rock. Chiefly used for ornamental purposes, but occasionally for heavy building work.—III. Most of the above stones are frequently used for decorative purposes, as has been noted under each example. The following, however, are rarely used for any other purpose than decoration:—(A) *Alabaster:* This is a form of GYPSUM (*q.v.*) It takes a fair polish, and is very often beautifully veined; but as it is very soft and not at all durable, it is only suitable for internal

decorative work, such as panels, vases, etc. (B) *Marbles:* A marble is a granular limestone capable of taking a high polish. Marbles used in statuary work are treated elsewhere. *See* STATUARY MARBLES. The following are amongst the commonest forms used in building:—(1) *Anglesea Marble:* A grained marble, containing also a certain amount of serpentine (*q.v.*) (2) *Black Marble:* Found in Ireland, at Galway and Kilkenny. (3) *Derbyshire Marble:* Occurs in a variety of colours, and is frequently finely marked. Much used in mantelpieces and other decorative work. (4) *Devonshire Marbles:* Both black and white marbles are found in North Devon. In South Devon marbles of various shades—grey, red, green, and rose—are found, and are worked for columns, panels, chimneypieces, etc. (5) *Purbeck Marble:* Blue or grey, containing shells and other fossils. Some good examples of this are seen in the Temple Church, London. (6) *Foreign Marbles:* There are an enormous number of these. Some of the best forms occur in Greece and in Italy, at Carrara and Massa, near the Bay of La Spezzia. (7) *Serpentine:* A fine stone of dark grey, variegated with other shades. Worked at the Lizard, in Cornwall, for columns, panels, and many varieties of small decorative work. The so-called "Connemara marble" is a serpentinous marble.—The geological nature of the above rocks will be found described under the respective headings, as are also the constituent minerals of each rock.

Building Up (*Eng.*) Making an object of a number of small pieces firmly attached together; thus large patterns are built up of glued pieces, and forgings are sometimes made out of a number of small pieces of iron welded together. To obtain the greatest strength, the component pieces are first arranged with the grain or fibre of alternate layers at right angles to each other.

Built Up Ribs (*Carp.*) Ribs (*q.v.*) composed of curved pieces nailed together side by side. A laminated truss.

Bulb (*Botany*). A specialised subterranean bud, consisting of a disc (stem) bearing overlapping succulent leaves.

Bulb Bars (*Eng.*) Bars of iron rolled with a bead parallel to their length, usually along one edge.

Bulge. An irregular protuberance.

Bulging Stress (*Eng., etc.*) The force tending to produce a bulge in sheets or plates, whether curved (as in a boiler) or flat.

Bulkhead. One of the upright partitions that divide the cabins in a ship; or that divide the hold into separate watertight compartments. The COLLISION BULKHEAD is that nearest the stern or bow of the ship.

—— (*Carp.*) The matchboarded space which lights the basement under the stall board (*q.v.*) in a shop; also a general term for a partition.

Bulla (*Archæol.*) A boss of metal, or even leather, worn by freeborn and noble Roman children until the age of seventeen, when they assumed the *toga virilis*.

Bull Dog (*Met.*) A mixture containing iron oxides, silica, etc., used for lining puddling furnaces (*q.v.*) The operation is termed "fettling."

Bulling Bar (*Mining*). A bar used as a ramrod for filling cracks with clay before blasting.

Bullion (*Bind.*) The same as boss (*q.v.*)

Bullion (*Cost.*) Heavy ornamental fringe, generally consisting of silk fabric covered with gold or silver wire.

—— (*Met.*) Precious metal in the mass as distinguished from manufactured articles or coined money.

—— (*Mining*). Pig lead which contains a certain amount of precious metal not yet separated by refining.

Bullion Point (*Glass Manufac.*) The extreme end of a bulb of glass which is being worked on a blowpipe. It is important that the bullion point be kept in line with the blowpipe during the early stage of manipulation.

Bullnose. A small metal rabbet plane, having the mouth or opening close to the front.

Bullnosed Bricks (*Build.*) Bricks having one angle on the end rounded off.

Bullnosed Step (*Carp. and Join.*) A step with a rounded end.

Bullock Gear, Horse Gear. The device used for driving machinery by animal power; the animal rotates a vertical shaft by means of a long lever, to which it is yoked.

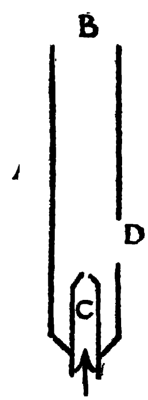
Bull's Eye (*Build.*) A small circular opening or window.

Bundle. In the cotton trade, a standard weight of cotton yarn consisting of a variable number of hanks, according to the counts, but always weighing 10 lb. in the grey state. A shipping bundle is sometimes 5 lb.

—— (*Linen Manufac.*) A standard length of 60,000 yards, containing two hundred cuts of yarn, is called a bundle, and it is by the bundle that linen yarn is usually sold.

Bunkers (*Eng.*) The spaces in which the coal for use on the voyage is kept in a steamship; sometimes the term is applied to a similar receptacle for use on land.

Bunsen Burner. A form of gas burner used when a hot but non-luminous flame is required—*e.g.* burners for laboratory purposes, gas stoves and furnaces, and for heating the MANTLE (*q.v.*) employed in the various forms of incandescent gas lighting. The essential principle of this form of burner is the mixing of the gas, before it reaches the jet where it burns, with a sufficient supply of air to secure complete combustion. The gas enters by a tube C, and in rushing up the tube A it draws in a continuous supply of air through the opening D, the size of which can be regulated in order to control the air supply. The mixture burns at B. In gas stoves the end B is closed, and a row of holes is pierced along the tube A, at each of which a portion of the gas burns with a small blue flame. Occasionally the burner "strikes back"—*i.e.* the gas catches light and burns inside the tube A. When this happens, the gas should be turned off and relit, as acetylene and other gases are produced, which are injurious and liable to explode.



BUNSEN BURNER.

Bunsen Cell. *See* CELLS, PRIMARY.

Bunsen Flame. *See* FLAME.

Bunsen's Ice Calorimeter (*Heat.*) Apparatus for measuring the heat given out by a body in cooling to 0° C. by observing the amount of ice melted by it. The ice is protected from external action by the vessel in which it is contained being surrounded by a second vessel, also containing ice; this absorbs any heat from the room, and prevents it from reaching the inner ice chamber.

Bunsen's Photometer (*Light*). Essentially a sheet of paper with a translucent grease spot in the centre. When the sheet is equally illuminated on both sides, the spot is indistinguishable; if the spot is viewed from the side which is less illuminated than the other, it appears brighter than the paper; if viewed from the brighter side of the paper, it appears darker, owing to the light passing through the spot instead of being reflected. *See* PHOTOMETERS.

Bunsen Valve. A simple arrangement for allowing gas to pass out of an apparatus and preventing air from entering. It is made by attaching a piece of rubber tubing to the end of the glass delivery tube, cutting a slit in the rubber longwise above the delivery tube, and pushing a piece of glass rod into the rubber tube as far as the slit, so that the rod extends the whole length of the slit.

Bunter (*Geol.*) A German name originally applied to the variegated and spotted strata occurring in the Upper New Red rocks. It has now come to be used for the lower division of the Trias (or Upper New Red), which commonly shows the variegation to which it owes the name. Similar variegations, however, occur in the sandstones of the Lower New Red, or Dyas, as well as in other rocks which have been formed under desert conditions.

Buntons (*Mining*). Horizontal timbers across a shaft.

Buoy (*Marine Eng.*) A hollow float anchored to the sea bottom; used to mark a shoal or to provide moorings for a vessel.

Buoyancy (*Phys. etc.*) Loss of weight due to immersion in a fluid: the upward force exerted on a body by a fluid in which the body is wholly or partially immersed. The force is equal to the weight of the fluid displaced, and in the case of a floating body is equal to the weight of the body itself. *See also* RESERVE OF BUOYANCY.

Bur. *See* BURR.

Burden (*Met.*) The charge given to a furnace. "Light burden" denotes excess of fuel; "heavy burden," excess of ore.

Burdiehouse Limestone (*Geol.*) A band of limestone of peculiar type, which occupies a position about halfway up the Lower Carboniferous rocks of the basin of the Forth. It is a finely laminated rock, which consists of alternate thin bands of chemically precipitated oolitic limestone, and others of a bituminous shale of the nature of oil shale. It underlies the chief part of the Oil Shale Series. It has long been celebrated on account of the well-preserved fossils which have been obtained from it.

Burette (*Chem., Phys.*) A graduated glass tube with some form of tap or stopcock; it is fixed vertically in a stand, and used for measuring a volume of liquid which has to be run into a vessel placed beneath the stopcock. Burettes capable of measuring from 50 to 100 cubic centimetres are much used in volumetric analysis.

Burganet, Burgonet (*Armour*). A helmet with a small visor, so constructed as to permit the head being turned either to right or left without the neck becoming exposed. First used by the Burgundians.

Burial (*Hygiene*). Places used for the purpose are sometimes offensive. This condition is brought about by the decomposition of animal matter, and is intensified by the agglomeration of bodies. Sickness is frequently caused by the contamination of both air and water. Burial grounds are under the control of the sanitary authority or burial board, who are authorised to make bylaws for the management, etc., thereof. They fall far short of cremation in hygienic value. *See also* CREMATION *and* SANITATION (DISPOSAL OF THE DEAD).

Burin *or* **Graver** (*Engrav.*) An instrument of tempered steel, with a square or lozenge-shaped point, used for engraving copperplates. The furrows cut by the square-pointed instrument are broad, and, not being deep and therefore not holding much ink, they give a grey print. The handle of the instrument is flat on one side, so that it can be held close to the plate when being used.

Burlap (*Dec.*) A coarse fabric stained in a variety of colours, and pasted upon a wall to give a uniform but broken surface. Hand stencilled friezes done directly upon the material are often used where a refined and uncommon decoration is desired.

Burner (*Motor Cars, etc.*) Oil (paraffin, petrol, etc.) is forced by air pressure or a small pump through coils of heated tubing, in which it becomes vaporised, to a gas burner, usually of the Bunsen type, giving a hot flame with very complete combustion. The vaporising coils must be heated when first starting the burner; but, once started, they are kept hot by the burner itself. *See also* OIL FUEL.

Burnett's Fluid. A solution of zinc chloride of specific gravity 2. It is used as an antiseptic.

Burnett's Process (*Eng., etc.*) The soaking or impregnation of timber with a dilute solution of zinc chloride, to increase its powers of resisting atmospheric influences.

Burning (*Eng., Met.*) Oxidation of iron by keeping it too long at a welding heat. Burnt iron is practically useless.

Burning Back (*Motor Cars*). The lighting of the vapour in an oil burner behind the jet in the tube of the burner. It is a somewhat dangerous occurrence, and the supply of fuel should be cut off at once, and the burner relighted after it has cooled down slightly.

Burning In Kiln (*Glass Manufac.*) A kiln used for burning in stain or enamel decorations on glass. It is generally heated by gas mixed with atmospheric air.

Burning Off (*Dec.*) Old paint work burnt off with a blow lamp.

Burning On (*Foundry*). A process of adding a fresh part to an injured or incomplete casting. A stream of molten iron is allowed to run through the mould of the new part of the casting until the surface where the junction is to be becomes fused. The flow is then stopped and the fluid metal in the mould allowed to cool. The process produces a kind of "weld."

Burning Out of a Machine (*Elect. Eng.*) The destruction of the insulation by overheating of the conducting wires of a dynamo, or motor, when too large a current passes.

Burnish (*Bind.*) The gloss on the edges of a book produced by a burnishing tool.

Burnisher (*Engrav.*) An instrument of polished steel with a blunt edge, used to reduce, soften, or remove faulty lines on an engraved copperplate.

Burnishing. Producing the highest state of finish on a surface by means of rubbing with special tools, usually of very bright smooth steel; but various stones, *e.g.* agates, are also used.

—— (*Photo.*) Effected by passing prints between polished steel rollers, or else by allowing the print to dry in close contact with a polished sheet of glass or ferrotype iron.

Burnt Ballast (*Build.*) Clay that has been burnt (calcined).

Burnt Iron *or* **Steel** (*Eng.*, *Met.*) Metal which has absorbed an excess of carbon by contact with the fire at a great heat. It is valueless.

"Burnt Out" Lace. Imitation guipure and similar lace made upon the embroidery machine. A woollen foundation is used to build the lace upon, this foundation being afterwards "burnt" or dissolved away in a solution of caustic soda or other chemical.

Burnt Sienna (*Paint.*) Sienna earth is burnt and is converted into a pigment of a fine orange-red colour. Used both in oil and water-colour painting. *See also* SIENNA.

Burnt Umber (*Paint.*) Umber is burnt and ground, producing a pigment of a reddish-brown colour. *See also* UMBER.

Burr (*Eng.*) The turned up and ragged edge of a piece of metal after cutting or grinding.

—— (*Engrav.*) The ridge of metal raised on the edges of a line by the cutting tool, generally removed, partially or altogether, by the scraper.

Burra Burra Copper (*Met.*) A blue form of Malachite or copper carbonate; a copper ore from Australia.

Burrs. *See* BRICKS.

Bursting (*Eng.*, *etc.*) As applied to pulleys and grindstones, it denotes a fracture due to the stresses set up by centrifugal forces when the object is rotating at a high speed.

Bush (*Eng.*) An anti-friction lining for a bearing, in one piece, very often cast *in situ*.

Bushel. *See* WEIGHTS AND MEASURES.

Buskin. (1) A half boot reaching to the knee, worn in classic times. Diana, Bacchus, and Mercury are frequently represented wearing buskins. (2) The thick-soled boot worn by actors in ancient Athenian tragedy, known as "Cothurnus," and distinct from the "sock" or low shoe worn by comedians. Hence "buskin" refers to the tragic art. (3) Also worn in the middle ages, especially by kings at coronation.

Bustle (*Paint.*) The opposite to repose. Absence of quiet and harmonious tones in composition of a picture.

Butanes, C_4H_{10}. There are two isomeric butanes—*viz.* NORMAL BUTANE, $CH_3CH_2CH_2CH_3$, and SECONDARY BUTANE (also called trimethylmethane), $\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CH-CH_3$. The first boils at 1°, and the second at −17°. Normal butane occurs in petroleum, and can be obtained by heating ethyl iodide with sodium. The second is obtained from tertiary butyl alcohol by making the iodide, and reducing this with nascent hydrogen. They belong to the paraffin series of hydrocarbons.

Butt (*Leather Manufac.*) The best part of the tanned hide; the back, after the belly and shoulders have been cut off. Used for soles of boots, belting, and heavy harness.

Butt Coupling (*Eng.*) *See* BOX COUPLING.

Butt Ended Spoke (*Cycle*). A spoke which has been thickened at the end before cutting the screw thread on it, in order that the strength of the screwed part may be as great as that of the rest of the spoke.

Butter (*Foods*). Is made from the fat of milk by churning. It is an article of food unfortunately very liable to adulteration. This is ordinarily done by admixture with other animal or vegetable fats. Occasionally potato and other starches are added. Water in quantity exceeding 16 per cent. is also regarded as adulteration. Composition: Fat, 82 to 87 per cent.; casein, milk, sugar, ·5 to 1·2 per cent. together; water, 9 to 15 per cent.; ash (including salt), less than 2 per cent. if the butter is "fresh," or 2·1 per cent. and over if "salt." The fat consists of compounds of glycerine with the following fatty acids: palmitic, stearic, oleic, butyric, caproic, etc. Butter owes its distinctive characteristics to about 7·8 per cent. of the glycerine compounds of butyric and caproic acids, etc. Butter is also adulterated with preservatives and colouring matter. The usual preservatives are boric acid and borax, or both. The colouring matter may be annatto, or "butter yellow," which is dimethylamidoazobenzene.

Butterfly Valve (*Eng.*) A couple of flap valves with their joint between them, like a common hinge.

Butt Joint (*Carp.*, *etc.*) A joint at right angles to its length. A plain joint without tongue or groove.

Button (*Eng.*) The piece punched out of a plate by the punching machine.

—— (*Watchmaking*). The knob fixed to the winding stem of a keyless watch.

Button Headed Screws (*Eng.*) Small screws with hemispherical heads.

Buttress (*Build.*) A mass of brickwork or masonry to prevent a wall being overturned. It acts as a permanent strut or SHORE (*q.v.*), and resists any thrust in an outward direction, *i.e.* at right angles to the plane of the wall.

Buttress Threads (*Eng.*) A thread whose section is a right-angled triangle, one face being at right angles to the shaft. They are used in screws which are to resist a force which is always in one direction.

Butt Riveting (*Eng.*) A riveted joint where the plates touch at the edge only, and a strip overlaps and is riveted to both of them.

Butt Strip (*Eng.*) The strip of plate used to cover a butt joint.

Butyl Derivatives. Compounds containing the group C_4H_9, derived from either of the two butanes (*see* BUTANES) by subtracting one atom of hydrogen. Thus isobutyl carbinol, the principal constituent of ordinary amyl alcohol (*q.v.*), would be $C_4H_9.CH_2OH$ $= \begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CH.CH_2.CH_2OH$.

Butyric Acids, $C_4H_8O_2$. Only normal butyric acid, $CH_3CH_2CH_2COOH$, is important. It is a rancid-smelling liquid boiling at 163°; soluble in water, alcohol, and ether. With alcohol and sulphuric acid it gives a smell of pineapples on warming. It is the characteristic acid of butter (*q.v.*) Formed in the fermentation of starch, sugar, and lactic acid by certain bacilli; on this account it is found in the

intestines. May be synthesised from ethyl aceto-acetate (*q.v.*) The smell of rancid butter is largely due to this acid.

Butyrin (*Chem.*)

$$\begin{array}{l} CH_2OOC.C_3H_7 \\ | \\ CHOOC.C_3H_7 \\ | \\ CH_2OOC.C_3H_7 \end{array}$$

Is the glycerine compound of normal butyric acid; forms one of the fats of butter (4·67 per cent. of butter fat).

B.W.G. (*Eng.*) The Birmingham Wire Gauge. *See* WIRE GAUGES.

By Products (*Gas Liquor*). *See* GAS MANUFACTURE *and* WASTE PRODUCTS.

Byssus (*Zoology*). A mass of adhesive threads secreted by a gland within the body of many bivalve shellfish. The byssus ("beard") serves as an organ of attachment.

Byzantine Architecture (*Architect.*) This style of architecture was developed at Byzantium in the fifth century A.D. The chief characteristics of Byzantine architecture are the extensive use of the dome and pendentive over large spaces: interiors richly treated with marbles, mosaics, and incised ornament. The finest example is the church of Hagia Sophia (A.D. 532—538) at Constantinople.

Byzantine Art. Greek and Roman art modified by Christian thought. Developed at Constantinople about 300 A.D., and during the Middle Ages was widely identified with all kinds of art, especially in Italy. It depended much on colour for its effect, and abounded with Christian emblems.

Byzantine Binding. Binding executed by the monks principally, before the invention of printing. Books being at this time extremely valuable, the bindings were often richly ornamented with paintings, gold and silver work, and even jewels.

Byzantines (*Coins*). *See* BEZANT.

C (*Chem.*) Symbol for CARBON (*q.v.*)

—— (*Music*). The first note in the scale of C. Its sol-fa name is Do, Doh, or Ut.

Ca (*Chem.*) Symbol for CALCIUM (*q.v.*)

Caaba. The name given to a stone building situate within the great Mosque at Mecca. Regarded with great veneration by Mohammedans as contain-the Black Stone or Keblah, presented by the Angel Gabriel to Abraham on the occasion of the building of the original Caaba. The entire building is sometimes called by this name.

Cab (*Eng.*) The shelter provided for the driver on a locomotive.

Cabinetmaking. The construction of the better class of furniture. It is distinguished from JOINERY by the greater variety of woods used, more elaborate ornamentation and finish, the use of VENEER (*q.v.*), and the difference in the construction of the joints. These are often much less scientific than in joinery, as neatness and general finish are of greater importance than strength.

Cabinet Picture. A small painting, generally highly finished, and admitting of close inspection.

Cabinet Size (*Photo.*) A print of which the size when finished is about 4 in. by 6 in., *i.e.* somewhat less than a HALF PLATE (*q.v.*)

Cable (*Architect.*) A convex moulding used on the lower part of the flutes of a column. The cables are usually one-third the length of the shaft in height. They were not used in Greek work.

—— (*Elect. Eng.*) A heavily insulated wire or set of wires, often protected from injury by a very strong covering. Used to convey large currents for lighting and power, or for the small currents required in telegraph or telephone work. In the latter cases a number of separately insulated conductors are often included in the one cable.

—— (*Eng.*) A stout rope of either hemp or steel. The name is also applied to a chain, especially that to which the anchor of a ship is attached.

—— (*Measure of Length*). *See* WEIGHTS AND MEASURES.

Cabled Column (*Architect.*) A column in which cables are used. It is also known as a RUDENTED COLUMN. *See* CABLE.

Cable Laid Rope (*Eng.*) A rope formed of several ordinary ropes, the whole being twisted in the direction opposite to the strands of the individual ropes.

Cable Moulding (*Architect.*) An enriched moulding consisting of a torus carved to represent a rope, used in Norman architecture.

Cable Railway (*Civil Eng.*) A cable extending the whole length of the track is placed either overhead or underground in a slotted conduit. The cars are drawn along by means of a clutch, which grips the cable when required, and releases it when the car is to stop. Cable railways are most suitable for short straight inclines.

Cable Tramcars (*Civil Eng.*) These use the central slot system. The cable runs in a roomy conduit under the slot, and is supported by pulleys 30 or 40 ft. apart. The clutch, when it seizes the cable, raises it above the level of these pulleys, and so passes them freely. The cable usually runs at 5 to 9 miles an hour. The most extensive system of cable tramcars in Great Britain is that of the city of Edinburgh; two of the most hilly routes in the city have been worked on this system for a long period, and in recent years the whole system has been thus equipped.

Cable Ways (*Civil Eng.*) Overhead cables, suitable for haulage of materials. The cable and gear are carried on trestles, which can, if necessary, be erected on broken and irregular ground, or carried over streams or ravines. The system is extremely useful for the carriage of materials used in the erection of bridges over wide rivers.

Cabling (*Cotton Spinning*). A process of doubling by which separate groups of threads are twisted together, then retwisted together so as to produce a round, even, and strong thread—*e.g.* sewing cotton thread.

Caboched *or* **Cabossed** (*Her.*) Affronté or full faced. When the head of the animal in a heraldic device is placed looking at the spectator and the neck is concealed; also called TRUNCKED.

Cabochon. A precious stone cut into plano-convex or concavo-convex form and polished, its natural shape being little altered; generally a garnet, ruby, sapphire, or amethyst.

Cacao (*Botany*). A name often applied to *Theobroma Cacao*, a tree of tropical America. *See* COCOA *and* THEOBROMINE.

Cachou de Laval. *See* DYES AND DYEING.

Cacodyl (*Chem.*) This word is used in two ways. (1) It is applied to the monovalent group $\begin{matrix}CH_3\\CH_3\end{matrix}{>}As-$, which has no independent existence, but enters into a number of compounds called after it, cacodyl compounds; *e.g.* $(CH_3)_2AsCl$ is CACODYL CHLORIDE. (2) It is applied to the compound formed by the union of the group $\begin{matrix}CH_3\\CH_3\end{matrix}{>}As-$ with another group like it, and thus having the formula $[(CH_3)_2As-As(CH_3)_2]$. This compound CACODYL, obtained by heating cacodyl chloride with zinc, is a liquid which boils about 170°: takes fire in air: its smell may induce vomiting: forms with slow access of air CACODYL OXIDE $\{(CH_3)_2As\}_2O-$, a compound also produced when arsenious oxide is distilled with potassium acetate. The oxide boils about 150°, has an appalling smell, and behaves like a basic oxide. CACODYL CHLORIDE, $(CH_3)_2AsCl$, is obtained by action of hydrochloric acid on cacodyl oxide; it is a liquid boiling about 100°, and its vapour produces terrible effects on the eyes and face when inhaled. CACODYL CYANIDE, $(CH_3)_2AsCN$, obtained by heating the chloride with mercury cyanide, is a solid melting at 33°; its vapour is fearfully poisonous. CACODYLIC ACID, $(CH_3)_2AsO.OH$, is formed by the action of mercuric oxide and water on cacodyl oxide; it is a deliquescent crystalline solid. Its sodium salt is used in medicine; it is less poisonous and has the same use as arsenious oxide. The group $\left(\begin{matrix}CH_3\\CH_3\end{matrix}{>}As-\right)$ behaves like a monovalent metal, and it is therefore an example of a compound radical (*q.v.*)

Cadaverine (*Chem.*). $CH_2{<}\begin{matrix}CH_2-CH_2-NH_2\\CH_2-CH_2-NH_2\end{matrix}$ (*Pentamethylenediamine*). Is found in putrefying corpses and in many kinds of putrid flesh, it is also found in pure cultures of the cholera bacillus. It is a colourless syrupy liquid boiling about 175°: has a peculiar smell: fumes in air: soluble in water and alcohol. It forms salts with acids, and is a diacid base. It is not poisonous except in very large doses. Has been made artificially. It is a PTOMAINE (*q.v.*)

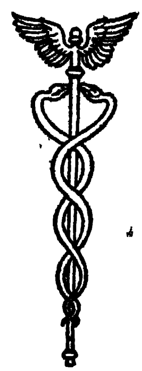
Cadence (*Music*). The close of a phrase, and the term applied to the two final chords of a musical phrase. There are four kinds. (1) PERFECT, when the chord roots are Dominant to Tonic. (2) Imperfect, when they are Tonic to Dominant. (3) Plagal, when the roots are Subdominants to Tonic. (4) INTERRUPTED, when the Dominant proceeds to some other root than Tonic.

Cadenza (*Music*). A free figure (generally written in small notes) introduced before a close.

Cadmium (*Chem.*), Cd. Atomic weight, 112. A white metal with bluish tinge; melts at 320°; boils about 770°; its vapour density shows it to have a monatomic molecule (*q.v.*) Easily soluble in hydrochloric, sulphuric, and nitric acids; burns in air when strongly heated, forming a brown oxide, CdO. It occurs along with zinc, and comes over with the first portions of that metal when distilled from its ores. To obtain cadmium, these first portions are redistilled and the product dissolved in hydrochloric acid and precipitated by sulphuretted hydrogen, when the yellow cadmium sulphide is thrown down. The sulphide is dissolved in strong hydrochloric acid, precipitated by sodium carbonate, the carbonate heated, and the resulting oxide distilled with carbon. Cadmium belongs to the same chemical family as zinc, which it closely resembles; the chief distinction is the yellow sulphide insoluble in dilute hydrochloric acid. It forms a constituent of FUSIBLE METAL (*q.v.*), and certain of its compounds furnish valuable pigments.

Cadmium Yellow (*Dec.*) A bright rich yellow pigment made from a salt of the metal cadmium by passing through it sulphuretted hydrogen. This yields the pigment which is sulphide of cadmium. It is permanent in oil, turpentine, water, and other vehicles, and may be mixed with any other pigments excepting white lead, the chromes, and those containing lead or (such as emerald green) copper. Made in three shades. Employed by artists and decorators, and rapidly increasing in use among the latter.

Caduceus (*Archæol.*) The staff carried by Mercury and symbolical of peace and prosperity. About it coiled two serpents, and to the top were attached extended wings.



CADUCEUS.

Cadus (*Archæol.*) A large jar of terracotta, used by the ancients for wine, oil, etc.

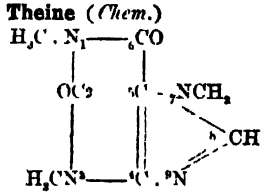
Cæcum (*Zoology*). A blind outgrowth from the junction of the ileum and the colon. It is largest in herbivorous animals. The end of the cæcum is termed the VERMIFORM APPENDIX.

Cælatura (*Art*). Latin for the art of carving bas reliefs, especially in metal: chasing or engraving.

Caen Stone. *See* BUILDING STONES.

Cæsium, Cs. Atomic weight, 133. A white metal spontaneously inflammable in air; it decomposes water. It belongs to the same group of elements as potassium, which it closely resembles chemically. This was the first metal discovered by spectrum analysis. It occurs in many mineral waters, and was first discovered by Bunsen in the waters of Dürkheim. Its spectrum is characterised by two bright blue lines, and from this circumstance it derives its name.

Caffeine *or* **Theine** (*Chem.*)



Forms long silky needles; melts at 233°; sparingly soluble in cold water, readily in hot. It is a feeble base. Acts on the heart, and is a diuretic. It is contained in tea (3 to 5 per cent.), coffee (1·3 per cent.: coffee-leaves much more). These beverages owe much of their effect to this substance. It may be obtained from tea by treatment with hot milk of lime, evaporating, extracting with chloroform, evaporating the extract, and crystallising from water. Test, similar to murexide test for uric acid (*q.v.*) Gives precipitates with alkaloid reagents (*q.v.*)

Cage (*Eng.*) The chamber or receptacle of a lift or winding gear of a mine; it is often made large enough to accommodate a considerable number of men or of waggons containing the material which is being removed from the mine.

Cage Valve (*Eng.*) A valve consisting of a spherical ball fitting into a seat of suitable form, and provided with a cover or cage of bent wire or bars, to prevent the loose ball from rising too far out of the seat.

Cainozoic (*Geol.*) Another name for the Tertiary period. It is correlative with AZOIC, EOZOIC, PALÆOZOIC, and NEOZOIC (*q.v.*) In Britain it is usually applied to all strata of newer date than those of Cretaceous age.

Cairn (*Archæol.*) A mound or heap of stones generally of conical shape. Sometimes erected over the graves of the dead or in commemoration of some remarkable event. Cairns are also erected in mountainous districts to serve as landmarks and to indicate the position of frontiers or other boundaries.

Cairngorm (*Min.*) A dark brown variety of QUARTZ (*q.v.*) much used in jewellery. The varieties used for this purpose are naturally almost opaque in the mass, but the colour is largely discharged by boiling in oil.

Caisson (*Eng.*) A water-tight chamber sunk into the ground under water. Masonry operations such as laying the foundations of bridge piers are carried on from within.

Caithness Flags (*Geol.*) The grey, micaceous, and somewhat bituminous flagstones which form a large part of the Orcadian Old Red Sandstone (the true Middle Old Red) in Caithness and Orkney. It is much quarried for pavements, and for any other purpose to which flagstones are usually applied. It yields a considerable variety of the fossil remains of the fishes which lived in the inland lakes of the period between that of the Upper Old Red and the Caledonian Old Red.

Cajeput (*Botany*). *Melaleuca leucadendron* (order, *Myrtaceæ*). A stimulant oil distilled from the leaves. The plant is a native of the Moluccas.

Caking Coal. Coal with much bituminous matter. Used in forges and in gasmaking.

Calabar Bean (*Botany*). *Physostigma venenosum* (order, *Leguminosæ*). A West African plant whose ripe seed yields the alkaloid PHYSOSTIGMINE, used in medicine.

Calamine (*Min.*) Carbonate of zinc; $ZnCO_3$; $ZnO=64{\cdot}8$, $CO_2=35{\cdot}2$ per cent. Called SMITHSONITE by some American writers and others. Commonly found as incrusting masses. It is the most important ore of zinc. Colour white, greenish, or brown, but very variable. Its crystallographic form is rhombohedral. From Cornwall, Cumberland, Derbyshire, Dumfriesshire; much also comes from Silesia, Carinthia, Spain, United States, etc.

Calando (*Music*). Decreasing the sound. When followed by *a tempo* it is used in connection with speed and means decreasing the pace.

Calantica (*Archæol.*) A headdress of Egyptian origin, consisting of a close-fitting cap fastened by a band passing round the head.

Calathus (*Archæol.*) A wickerwork basket used by the Grecian women to hold their wool for spinning.

Calcareous Rocks (*Geol.*) Rocks consisting wholly, or in part, of carbonate of lime. The term includes all limestones and most true marbles, as well as a considerable variety of sedimentary rocks into whose composition carbonate of lime enters.

Calceus (*Archæol.*) A shoe or half boot worn by the Romans. It differed according to the rank or official position of the wearer.

Calciferous Sandstones (*Geol.*) A term applied to the lower part of the Lower Carboniferous Rocks of the south of Scotland before their true geological position was known. They are chiefly of estuarine origin. They contain but little lime, and consist largely of shales. The upper part of the rocks in question is the horizontal equivalent of the Mountain Limestone, while the lower part is contemporaneous with the Lower Limestone Shales. Important groups of volcanic rocks occur in these strata in Scotland.

Calcination *or* **Roasting** (*Met.*) Heating an ore without causing fusion. It is an important operation in connection with many ores, whereby various constituents (*e.g.* carbon, sulphur, arsenic, etc.) are converted into gaseous substances and expelled in this form; in addition to this object, some ores are calcined in order to effect the oxidation of the metal itself.

Calcining Furnace (*Met.*) A reverberatory furnace (*q.v.*) used for calcination or roasting.

Calciphyres (*Geol.*) A term sometimes applied to certain marbles which have undergone a considerable amount of METAMORPHISM (*q.v.*) and in which new silicates have consequently been developed.

Calcite (*Min.*) Calcium carbonate in the rhombohedral form (*cf.* ARAGONITE), $CaCO_3$, $CaO = 56$, $CO_2 = 44$ per cent. It occurs crystallised in a great variety of forms, and massive as STALACTITES and incrustations in caves. The pure variety, ICELAND SPAR, is very valuable on account of the demand for it for the manufacture of polariscopes. ORIENTAL ALABASTER is a stalagmitic variety, and is used under the name ALGERIAN ONYX for ornaments. Calcite is a very common gangue metal (*q.v.*) in metalliferous veins. Calcite shows very marked double refraction. It is very widely distributed all over the world.

Calcium, Ca. Atomic weight, 40. One of the most abundant elements; contained in chalk, marble, limestone, dolomite, alabaster, selenite, etc. (*q.v.*) It is obtained as a brilliant white crystalline solid by heating calcium iodide with excess of sodium in an iron crucible. The excess of sodium, which, while molten, serves as a solvent for the calcium, is removed by gradually adding the contents of the crucible, when cold, to absolute alcohol. Calcium burns in air to form the oxide CaO (QUICK LIME), and rapidly combines with water, forming SLAKED LIME, $Ca(OH)_2$. Heated in hydrogen it forms the white hydride CaH_2.

Calcium Compounds. CALCIUM OXIDE, CaO (QUICK LIME), a white amorphous solid, combines with water to form the hydroxide $Ca(OH)_2$. It is obtained by heating the carbonate or the nitrate; is a typical basic oxide. CALCIUM HYDROXIDE, $Ca(OH)_2$ (SLAKED LIME), is a white powder sparingly soluble in water. The clear solution is called LIME WATER; the turbid mixture of the hydroxide and water is called MILK OF LIME, used in making mortar (*q.v.*) Both solid and solution absorb carbon dioxide from the air. CALCIUM CHLORIDE, $CaCl_2$: A white deliquescent solid, prepared by dissolving the carbonate in hydrochloric acid and evaporating to crystallisation when $CaCl_2 6H_2O$ is deposited. On heating these crystals, $CaCl_2$ remains. Combines with ammonia gas to form $CaCl_2 8NH_3$. Used as a drying agent. CALCIUM CARBONATE, $CaCO_3$: Natural forms are

chalk, limestone, marble, calcite, aragonite (*q.v.*) Prepared by adding sodium carbonate solution to calcium chloride solution and washing the precipitate with water (PRECIPITATED CHALK). Solubility in water less than 1 in 10,000; but in presence of carbon dioxide dissolves readily, owing to formation of CALCIUM ACID CARBONATE, $Ca(HCO_3)_2$. It is the presence of this latter compound that causes TEMPORARY HARDNESS in water. As it is decomposed on boiling or addition of lime water, these operations remove temporary hardness. Calcium carbonate is decomposed, on heating, into quick lime, CaO, and carbon dioxide; also it dissolves in acids forming carbon dioxide, water, and the calcium salt of the acid. CALCIUM SULPHATE, $CaSO_4$: Usually met with as $CaSO_4 2H_2O$. *See* GYPSUM, ALABASTER, SELENITE. A white solid soluble to extent of 1 in 480 of water. When present in water it causes PERMANENT HARDNESS. May be prepared by adding sulphuric acid to a solution of calcium chloride and washing the precipitate. When *Gypsum*, $CaSO_2 2H_2O$, is heated, it forms PLASTER OF PARIS, $2CaSO_4 . H_2O$, which, when mixed with water, "sets," owing to re-formation of $CaSO_4 2H_2O$. The sulphate heated with carbon forms CALCIUM SULPHIDE, CaS –, a white powder which, when exposed to sunlight and then removed to a dark room, becomes luminous (CANTON'S PHOSPHORUS). CALCIUM PHOSPHATE, $Ca_3(PO_4)_2$ (*see* PHOSPHORITE, APATITE, ESTRAMADURITE), is the principal constituent of bone ash (*q.v.*) May be prepared by adding ammonia and solution of sodium phosphate to solution of calcium chloride. White solid, insoluble in water and soluble in acids. When treated with sulphuric acid according to the equation $Ca_3(PO_4)_2 + 2H_2SO_4 = CaH_4(PO_4)_2 + 2CaSO_4$, the resulting mixture of calcium acid phosphate and calcium sulphate is called SUPERPHOSPHATE OF LIME, and is largely used as a manure. CALCIUM PHOSPHIDE is obtained along with calcium phosphate when vapour of phosphorus is passed over heated quick lime. Water decomposes it, forming spontaneously inflammable phosphoretted hydrogen, which burns with a bright white light; hence the use of the phosphide for signal lights at sea.

Calender (*Paper Manufac.*) A stack of superimposed rolls used for imparting a polished surface to finished paper.

—— (*Textile Manufac.*) A machine used in the starching and dressing of cotton fabrics. It consists of a number of rollers under pressure and in contact with each other.

Calendered Paper. Paper with a glazed surface, generally used for the printing of illustrated works.

Calender Rollers (*Woodworking*). The rollers by which wood is fed into various forms of woodworking machinery.

Calf (*Bind.*) A superior kind of leather made from calfskin and used in bookbinding. It is frequently coloured or marbled. *See* VELLUM.

——, **Box** (*Leather*). *See* BOX CALF.

Calf Kid. Calfskins dressed with alum, salt, flour, and egg yolk. Afterwards dyed black on grain side. Formerly largely used for uppers of boots.

Calibration (*Phys., etc.*) A determination of the correct value of the graduations of a scale or some measuring instrument; or a determination of the dimensions of an object which is to be used as a standard of measurement.

Caliche (*Chem.*) A name given to CHILI SALTPETRE: naturally occurring sodium nitrate.

Calico. A cloth in which the warp and weft are alternately interlaced, thus forming a strong and firmly bound cloth. It is used in its grey state, also in the dyed, printed, and bleached states. Its method of interlacing is known as a "plain weave." The name is derived from the town of Calicut in India.

Caliga (*Archæol.*) The strong heavy shoe worn by Roman soldiers.

Caliver (*Arm.*) A light gun resembling an arquebus, but having a wider bore. It was used first in the sixteenth century.

Calix (*Archæol.*) A shallow Grecian drinking cup having two handles: hence chalice.

Calking *or* **Caulking** (*Eng.*) Filling the openings of the seams of a ship, boiler, etc., either by burring the edge of the plates or by driving in some substance to fill up the crevices.

Calligraphy. Handwriting or penmanship. Perhaps the finest examples of handwriting are to be found in the manuscripts of the middle ages.

Calliope (*Eng.*) A modulated steam whistle used on American steamboats.

Callipers. A tool for measuring the internal or external diameter of objects. Two varieties, known as INSIDE and OUTSIDE CALLIPERS, are commonly used: these resemble in principle a pair of compasses, but the legs are curved so as to turn the points outward in the first case and inward in the second. A more modern form consists of sliding trammels (*q.v.*) on a straight bar, resembling a pair of beam compasses (*q.v.*) The bar is often graduated, and one of the trammels fitted with a fine vernier (*q.v.*) for exact measurements.

Callipygian Venus (*Art*). The name of a celebrated statue of Venus in the Farnese Palace, Rome.

Calmato (*Music*). Calmly.

Calme *or* **Came** (*Building*). The bars of lead-glazed windows, in which the glass is fixed.

Calomel (*Min.*) Mercurous chloride, HgCl. It is rather a rare mineral; the drug of the same name is an artificially prepared compound. *See also* MERCURY COMPOUNDS.

Calorescence (*Heat, Light*). The absorption by a substance of radiation of a given wave length and its subsequent emission as radiation of less wave length; *e.g.* invisible infra-red radiations absorbed by a piece of platinum foil can cause it to become incandescent: the energy of the long and invisible waves is given off as visible waves of shorter wave length.

Caloric (*Phys.*) Heat was at one time regarded as an elastic fluid, and the name Caloric was used to denote this substance.

Calorie (*Phys.*) The unit of heat generally used in scientific work. It is (for most practical purposes) the amount of heat necessary to raise 1 gram of water through 1° C. For very accurate work it is necessary to specify the exact temperature at which the water is taken, as the specific heat of water varies. The temperature most usually agreed on is 4° C., but other temperatures have been used from time to time.

Calorific Value (*Heat, etc.*) The measure of the amount of heat obtainable from a given weight of fuel. It is usually found by direct experiment, the fuel being completely burnt and the heat evolved measured by some form of calorimeter.

Calorimeter (*Phys.*) An instrument for measuring actual quantities of heat. In its commonest form it consists of a thin metal vessel, in which a known mass of water (or other liquid) is placed. The rise or fall in temperature of this liquid (due to the introduction of a hot or cold body) is observed by means of a thermometer. The vessel is usually protected from loss or gain of heat through radiation by means of an outer vessel. *See also* BUNSEN'S ICE CALORIMETER, STEAM CALORIMETER, *etc.*

Calotte (*Art, etc.*) A term for the smaller section of a sphere, not used in scientific phraseology. Also used to denote the small SKULL CAP of an ecclesiastic.

Calpis (*Pot.*) A Grecian earthenware vessel of large size, having three handles, used for holding water.

Caltrap, Caltrop, *or* **Galltrap** (*Archæol, etc.*) (1) An instrument of iron with sharp projecting points, laid on the ground in battle to wound the feet of the enemy's horses. (2) A trap or gin. (3) Sometimes used as a charge in heraldry.

Calumba Root (*Botany*). *Jateorhiza calumba* (order, *Menispermaceæ*). The tonic drug is prepared from the dried roots of a trailing plant from the forests of East Africa.

Calyx (*Botany*). The outer whorl of floral leaves (SEPALS) in a flower. It has usually a protective function.

Cam (*Eng.*) An eccentric rotating plate, or a projection, or a slotted rotating shaft, used to produce some required reciprocating motion of an intermittent or irregular character.

Camaieu. (1) The same as CAMEO (*q.v.*) (2) A painting or engraving in monotone.

Camail (*Armour, etc.*) (1) The chain mail armour attached to the bascinet helmet, worn during the fourteenth and fifteenth centuries. It protected the sides of the head and the neck, and covered the shoulders like a tippet. (2) A headdress which was worn by priests in winter.

Camber (*Build.*) The extent to which a horizontal beam is curved upwards in the centre. For cast iron, $\frac{3}{4}$ in.; wrought iron and steel, $\frac{1}{2}$ in. to every 10 ft. of span. Also a general expression for the amount of curvature of an arch, etc.

Camber Arch (*Architect.*) An arch rising $\frac{1}{8}$ in. to every foot of span, and straight on the top. In some cases the curvature is entirely omitted; the separate voussoirs then form a straight structure which serves instead of a single large stone or beam.

Cambered (*Carp., Build., etc.*) Raised in the centre: slightly curved or arched.

Camber Slip (*Build.*) A mould or template (*q.v.*) used for cutting a camber arch.

Cambium (*Botany*). The layer of living formative tissue lying between the wood and soft bast of a vascular bundle in a Dicotyledon. The layer which gives rise to the cork is termed CORK CAMBIUM or PHELLOGEN.

Cambrian System (*Geol.*) A group of ancient rocks, chiefly consisting of marine sediments, which were formed after the close of Archæan times and before the Ordovician period. The lowest beds are usually characterised by TRILOBITES (*q.v.*), allied to *Olenellus*, the middle by *Paradoxides*, the upper by *Olenus*. These rocks are of great interest as showing examples of each group of invertebrate animals, even though they lie at or near the base of those which yield traces of life.

Cambric. A fine light plain-texture linen material, more closely woven than lawn, and chiefly used for handkerchiefs. Originally made at Cambray in Flanders.

Cambro-Silurian Rocks. A name applied by Jukes to the rocks now called ORDOVICIAN (*q.v.*), which lie between the true Cambrian Rocks and those of Silurian age, and whose included fossils differ materially from those of the formations above and below.

Camel Hair. This material is used for artists' brushes. It is also a trade name for a kind of yarn composed of wool and hair, used in the weaving of driving belts (*q.v.*)

—— (*Woollen Manufac.*) The sorted hair of the camel usable in the manufacture of yarn for weaving purposes.

Cameo. Usually a design in relief, produced by cutting to various depths into a substance which consists of thin laminæ of different colours. It is generally a shell (one of the *Gasteropods*), but onyx is used also.

Caméoid (*Dec.*) A popular relief decoration for walls and ceilings, made by moulding paper materials.

Camera (*Music*). Secular, as distinguished from CHIESA, sacred. *Concerto di camera* was for performance in a room; *Concerto di chiesa* for performance in church.

Camera Lucida. An optical device by which a virtual image (*q.v.*) of an object (which may be a microscope slide, etc.) is seen on a sheet of white paper placed underneath the instrument; the image is usually viewed with one eye, so that a pencil can be used at the same time to make a drawing of the object. The optical effect is usually produced by a prism which causes total internal reflection of the rays proceeding from the object. When used for drawing an object under the microscope, the prism is fixed at, or above, the top of the tube, with its axis at right angles to the axis of the microscope.

Camera Obscura. This consists of a convex lens fixed in an aperture in the centre of the wall, or in the roof, of a small room from which light is excluded, an image of scenery outside being thrown by the lens on the opposite wall or on to a table standing beneath the lens. The camera obscura is merely an optical toy or curiosity, on the principle of the ordinary photographic camera.

Camera, Photographic. *See* PHOTOGRAPHIC CAMERA.

Cameron's Sewage System. *See* SEPTIC TANK SYSTEM.

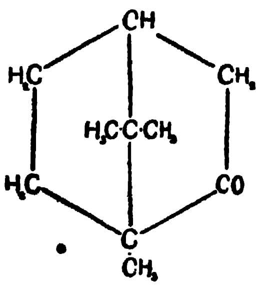
Campaign (*Met.*) The period during which the lining of a blast furnace can last.

Campanes (*Her.*) Bells suspended to charges.

Campaniform Capital (*Architect.*) One of the types of capitals used by the Egyptians. Its form resembles that of an inverted bell or a fully developed lotus flower. *See* HATHOR HEADED, CLUSTERED LOTUS, LOTUS, *and* PALM CAPITALS.

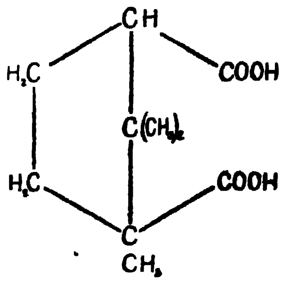
Campanile (*Architect.*) A tower erected for the use of bells. The term is applied especially to the detached towers built for this purpose in Italy. A notable instance was the Campanile of St. Mark's, Venice, now being rebuilt.

Camphor (Common *or* Japan Camphor). A colourless translucent crystalline solid; characteristic smell; melts at 175°; volatilises even at ordinary temperatures; sp. gr. ·99; soluble 1 in 700 water; readily soluble in oils, alcohol, etc. Alcoholic solution is dextrorotatory (*q.v.*) Used in medicine. It is obtained by distilling wood of camphor tree with steam, pressing and subliming distillate; also by oxidising BORNEO CAMPHOR with nitric acid.



CAMPHOR.

Yields CYMENE (*q.v.*) when distilled with phosphorus pentoxide; boiled with iodine, yields CARVACROL (*q.v.*); reduction converts it into Borneo camphor; oxidation yields chiefly CAMPHORIC ACID, an optically active dibasic acid. ARTIFICIAL CAMPHOR (so-called) is PINENE HYDROCHLORIDE, $C_{10}H_{17}Cl$; made by passing hydrochloric acid gas into well cooled pinene (*q.v.*) It is a white crystalline mass with an odour like that of camphor; melts at 125°. BORNEO CAMPHOR (BORNEOL) is related to camphor as shown in the formulæ:



CAMPHORIC ACID.

$$C_8H_{14}\left\langle\begin{matrix}CO\\ |\\ CH_2\end{matrix}\right. \qquad C_8H_{14}\left\langle\begin{matrix}CHOH\\ |\\ CH_2\end{matrix}\right.$$

Camphor. Borneol.

Its chief source is a tree, *Cinnamomum camphora* (order, *Lauraceæ*), growing in Borneo and Sumatra. It is a white solid melting at 203°, and smelling of camphor and peppermint. Can be converted into and obtained from common camphor. *See* above.

Camptonite (*Geol.*) A name given to one of the numerous varieties of MICA TRAP (*q.v.*), which in this case has affinities with the DIORITES (*q.v.*) It has a microgranitic ground mass, and contains plagioclase and hornblende (*q.v.*) Much of what used to be called Camptonite would now be comprehended under the useful general term PORPHYRITE.

Camwood. *See* DYES AND DYEING.

Canada Balsam. A transparent resinous fluid, very viscous, and hardening into a clear transparent solid, whose refractive index is about equal to that of glass, 1·53. It is obtained from the Balsam Fir of North America, *Abies balsamea* (*Coniferæ*). It is much used in optics for cementing lenses together, mounting microscopic objects, etc.

Canal (*Biology*). A hollow cavity or channel for the passage of a liquid or a gas through the tissues of an organism.

—— (*Civil Eng.*) An artificial waterway with LOCKS (*q.v.*) for crossing raised ground, and a supply of water at its highest levels to compensate for water allowed to escape from the locks.

Canary Grass. *Phalaris canariensis* (order, *Gramineæ*). The grass is extensively grown in England, and also imported from other countries. The seed is used for cage birds.

Canary Wood. *See* WOODS.

Cancels (*Typog.*) Pages that have been reprinted owing to an error, literary or technical. Usually indicated by an asterisk at the foot of the page.

Cancer, Tropic of (*Astron.*) *See* TROPICS.

Candelabrum. A candlestick, generally an ornamental one. A branched candlestick holding a number of candles.

Candle. Formerly candles were made from tallow by repeatedly dipping the wicks, suspended from a frame, into a tank of tallow kept in a liquid state by heat. Tallow candles are still made, principally for use in mines and in workshops, a coloured thread being often introduced into the wick to distinguish the works in which they are used and to prevent pilfering. Candles are now usually made from stearin or paraffin wax (*q.v.*), or a mixture of both, by moulding in special frames or machines. Sometimes small quantities of ozokerite (*q.v.*), ceresine, and other waxes are employed. Candlemaking machines are mostly arranged in such a manner that a continuous supply of candles is produced. The wicks are run off from bobbins, passed through orifices, and are held exactly in the centre of a series of hollow cylinders equal in diameter to the candle. The molten wax enters the moulds, cold water is then admitted into the space surrounding the moulds, and quickly cools the wax, and the candle is formed. The candles are raised out of the moulds by means of a lever, the wicks following ready for the next moulding. Some machines make a conical cap or end to the candle to hold it more firmly in the candlestick. The wicks are usually plaited, and are treated with a solution of borax and sulphate of ammonia, which causes them to burn without guttering or leaving an ash. Candles are now made in a large variety of shapes and sizes, special mixtures of waxes being employed for those intended to be used in hot climates. As illuminants candles occupy the lowest place, on account of the impurity they add to the air during combustion. A candle of standard size yields on combustion nearly half a cubic foot of carbon dioxide and water. *See also* ARTIFICIAL ILLUMINATION.

Candle Flame. *See* FLAME.

Candle, Standard. *See* STANDARD CANDLE.

Cane (*Botany*). *Calamus*—various species (order, *Palmæ*). Under the name of cane the stripped stems of various slender palms are imported for making chair bottoms, baskets, etc. The term RATTAN CANE is also employed.

—— (*Silk Manufac.*) *See* WARP.

Canephorus, Canephora. In ancient Grecian festivals one of the maidens who carried on their heads the implements of sacrifice, etc.

Cane Sugar (*Chem.*), $C_{12}H_{22}O_{11}$ (*Saccharose*). Occurs in juice of sugar cane (20 per cent.), of the beet (10 to 20 per cent.), of the maple and other plants. To obtain the sugar the juice is extracted from the cane or beet by a process of diffusion. It is then treated with milk of lime to separate albumins and neutralise acid; with sulphur dioxide to prevent fermentation; and then decolourised by filtration through animal charcoal. After concentration it is evaporated in vacuum pans (*q.v.*) till it deposits, on cooling, sugar crystals termed RAW SUGAR. The raw sugar is refined by what is practically a repetition

of the above treatment of the juice. Sugar may be obtained from the molasses by a process of diffusion or by adding strontia (SrO), which forms a solid with the sugar of the molasses, insoluble in cold water. This solid ($C_{12}H_{22}O_{11}SrO$) is filtered, washed, pressed, suspended in water, and decomposed by carbon dioxide, giving insoluble strontium carbonate and a solution of sugar which can then be crystallised. Sugar is a white crystalline solid soluble at the ordinary temperature in $\frac{1}{3}$ part water; its solution is dextrorotatory (*q.v.*) Sugar melts at 160°; allowed to solidify, it forms barley sugar. Heated above its melting point it loses water, and about 200° forms a brown substance called CARAMEL, which is an indefinite mixture of compounds soluble in water, precipitated by alcohol, much used in colouring sweets, soups, etc. Cane sugar has no reducing properties (*cf.* MALTOSE *and* LACTOSE). Dilute acids "invert" it—*i.e.* change it to a mixture of DEXTROSE and LAEVULOSE (*q.v.*) by addition of water, $C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6$. This mixture is lævo-rotatory, hence the term "inversion." Yeast first inverts cane sugar and then ferments the dextrose and lævulose, forming chiefly alcohol and carbon dioxide. Cane sugar yields an acetate with acetic anhydride; a nitrate with nitric acid. Heated with excess of nitric acid, it gives oxalic acid.

Cannel Coal. *See* COAL.

Cannets (*Her.*) Ducks without feet or beaks.

Cannon (*Eng.*) In engineering, a hollow shaft through which passes another shaft, which has some motion independent of that of the cannon.

Cannon Pinion (*Watchmaking*). The pinion to which the minute hand of a watch is fixed.

Canon (*Art, Science, etc.*) Denotes rule or law. It is applied to any art or science that is governed by fixed laws. The laws of the Church are called CANONS.

—— (*Music*). A composition in which the strictest imitation of the opening passage or pattern is maintained at various intervals, and may be in two, three, four, or any greater number of parts. In some cases all the voices take part in Canon, as in the well known grace, Byrd's "Non nobis Domine"; in other cases only a part of the voices are in Canon, whilst the accompanying parts are free, as in Tallis's Hymn-Canon "Glory to Thee, my God." The study of Canon is especially useful to the student for Fugal writing. Canons are "infinite" when they lead back to the beginning, and "finite" when ending either naturally or by means of a Coda.

—— (*Typog.*) One of the largest kinds of type. *See* TYPE.

Canopic Vase *or* **Canopus** (*Archæol.*) A vase used by the Egyptians for preserving the viscera of the dead.

Canopy (*Architect., etc.*) An ornamental roof or covering over niches, etc., used in Gothic architecture. A covering or hanging suspended over a person or object. *See* BALDACHINO *and* TABERNACLE.

Cant (*Carp., etc.*) (1) An obtuse angle. (2) A slope, tilt, or inclination.

Cantabile, Cantando (*Music*). In a singing manner.

Cant Brick (*Build.*) A brick cut on the splay—*i.e.* at any angle other than a right angle.

Cantharides (*Zool.*) *Cantharis vesicatoria* (order, *Coleoptera*). The dried beetle ("Spanish blister fly") is used in medicine as a blistering agent.

Cantharus (*Pot.*) A Grecian two-handled drinking vessel varying in form and dimensions. Bacchus, the god of wine, generally is represented with one.

Cantilever (*Civil Eng.*) A projecting beam or girder, supported at one end only; it is usually built into a wall or other structure.

Cantilever Bridge (*Civil Eng.*) A bridge constructed of two or more CANTILEVERS (*q.v.*), which meet in the centre of the span, but do not depend on each other for support. The Forth Bridge, Edinburgh, is the finest example of a cantilever bridge in the world.

Canting (*Eng.*) Tilting or causing a slope.

Canting Arms (*Her.*) Allusive armorial bearings; also called a REBUS.

Canto Fermo (*Music*). Fixed song or melody; that melody to which other melodies are added in counterpoint.

Canton (*Her.*) A division of the shield, and one of the honourable ordinaries. It is placed in a corner of the shield, and its size is one-third of the chief.

Cantoned (*Architect.*) A term applied to a building or pier which has its angles emphasised by means of pilasters, columns, or rustic work.

—— (*Her.*) A saltire, or cross, placed between four charges is said to be cantoned. It also denotes a single charge placed in the first quarter of the shield.

Canton's Phosphorus (*Chem.*) *See* CALCIUM SULPHIDE, *under* CALCIUM COMPOUNDS.

Cantoris (*Music*). That side of a choir on which the cantor, or chanter, sits. The opposite side to DECANI. It is the left side, looking east.

Canvas Wall Hangings (*Dec.*) A plain canvas material having a specially prepared surface formed by rolling the fabric, and an adhesive backing to facilitate hanging on walls. BURLAP, CRASH, and FABRIKONA are the best known varieties. Made in various colours, and often used with a stencilled frieze done in bright colours upon the fabric.

Caoutchouc. The South American name for the coagulated milky sap of several plants of tropical origin belonging to the order *Euphorbiaceæ*. There are over fifty varieties of Caoutchouc which may be roughly classed in order of importance as African, South and Central American, Asiatic and Oceanic. It is an elastic gummy tenacious substance. Being impervious to the action of water and atmosphere, and largely so to acids and alkalis, it is used in many arts and manufactures. Originally used for erasing pencil marks, it is now very extensively employed industrially. The material is obtained by cutting incisions in the trunk and collecting the juice; it is dried by careful exposure in thin layers to the heat of a smoky flame. When pure it has the formula $(C_5H_8)x$; on distillation it yields ISOPRENE, C_5H_8; undergoes oxidation on exposure to moist air in presence of light; heated above 120° it softens, and does not again become hard. It is soluble in benzene and its homologues toluene and xylene, in turpentine, petroleum spirit, carbon disulphide, chloroform, etc. Treated with chloride of sulphur or with certain metallic sulphides and sulphur (*e.g.* antimony penta-sulphide, Sb_2S_5), part of its hydrogen is replaced by sulphur, and the product is VULCANISED RUBBER. Vulcanised rubber deteriorates from slow oxidation, the rubber becoming brittle, owing to formation of resinous substances. *See* RUBBER.

Cap (*Bind.*) An envelope of paper to protect the edges of a book while being bound.

—— (*Build.*) The coping stone on the top of a shaft or pier. *See also* CAPITAL.

—— (*Carp. and Join.*) The turned end of a handrail that is fixed on top of a NEWEL (*q.v.*)

—— (*Eng.*) A general term in engineering for a cover, or the loose upper part of an object—*e.g.* the upper part of a plummer block or shaft bearing, which holds the brasses in position.

—— (*Gasfitting, etc.*) A tubular cover with a female thread to stop the end of a gas or water pipe.

—— (*Mining*). Rock, covering the ore in a vein.

Capacity, Electrical. The quantity of electricity required to charge a conductor up to unit potential (*q.v.*); or, in other words, the ratio of the charge on a conductor to its potential.

Cap-à-Pie (*Arm., Her.*) Completely armed, from head to foot.

Caparison (*Arm., etc.*) (1) The defensive armour which was used for horses. (2) An ornamented cloth for covering a saddle: also the housings or trappings covering a horse, especially on State occasions.

Capers (*Botany*). The capers of commerce are the flower buds of *Capparis spinosa* (order, *Capparidaceæ*). The plant grows in Southern Europe.

Capillarity. The surface of a liquid behaves as if it consisted of a thin film, capable of being stretched to an infinite extent, but always exerting the same tensile force across each centimetre. This force is called SURFACE TENSION: its value varies with different liquids: for water it is 81 dynes per centimetre, if the water is clean and in contact with air. If a solid which is not wetted by any given liquid is laid upon it, the existence of this film becomes apparent; for example, a piece of iron laid upon mercury shows clearly the kind of hollow which would be produced by an object lying on a slightly stretched membrane, and the same thing can even be seen if a needle with a slightly greasy surface be laid upon water, when it will remain held up above the surface, which can be seen to curve down under it. If a tube be pushed down into a liquid, one of two things will occur. If the liquid does not wet the tube, as in the case of a glass tube plunged into mercury, the level of the liquid inside will be lower than the level outside. This is termed CAPILLARY DEPRESSION. The greater the diameter of the tube, the less the depression. This is much the same result as would obtain if we pressed a similar tube down on a stretched elastic membrane. The analogy, however, is not completely true, as the hydrostatic pressure of the liquid has to be taken into account. The effect of this is shown in fig. 1. A is the level of the liquid outside the tube and B the level inside. At the level B there is a hydrostatic pressure upward, due to the column of liquid of height AB. In the absence of any tension of the film on the surface the liquid at B would rise to the height A, and become equal inside and outside. But as the tension is present, the liquid inside rises to such a height that the upward pressure is just balanced by the downward force due to the tension of the surface. In fig. 2 is shown the case of a tube immersed in a liquid which wets its surface. In this case the liquid tries to spread itself out over the greatest possible amount of surface of the tube, and this results in an upward force at AA, which draws a column of liquid of height AB up the tube. The upward force due to surface tension is exactly counter-balanced by the downward force due to the weight of a column of liquid AB. If r is the radius of the tube, then its circumference is $2\pi r$; if T represent the tension across 1 cm., then the total tension at AA is $2\pi r\mathrm{T}$, as it exists right round the circumference of the tube. The weight of the liquid column is equal to its volume multiplied by its density—that is, $\pi r^2 h\rho g$. We thus get the following equation:

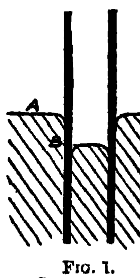


FIG. 1.
CAPILLARITY.

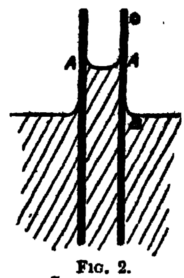


FIG. 2.
CAPILLARITY.

$$2\pi r\mathrm{T} = \pi r^2 h\rho g$$

therefore
$$\mathrm{T} = \frac{\pi r^2 h\rho g}{2\pi r} = \tfrac{1}{2} r h\rho g$$

From this we can calculate the amount of the surface tension, as all the quantities on the right hand side are easily observed. It is also evident from the equation that the product rh is constant; therefore the diameter of the tube and the height of the column are in inverse proportion—*i.e.* the narrower the tube the higher the column of liquid which rises in it.

Capillary (*Zoology*). Minute thin-walled blood-vessels which ramify in great numbers through the tissues.

Capillary Electrometer (*Elect.*) A form of electrometer (*q.v.*) depending on an alteration produced by a change in potential in the surface tension between mercury and dilute sulphuric acid. It is chiefly of scientific interest, and is rarely used in practice.

Capital (*Architect.*) The uppermost member of a column or pilaster between the shaft and the feature supported. When one feature crowns another the former is sometimes referred to as the capital of the latter. *e.g.* Capital of Guttæ (*q.v.*) *See* ARCHITECTURE, ORDERS OF: COLUMN: DORIC, *etc.*

Capital Letters (*Typog.*) *See* CAPS.

Capital of Guttæ (*Architect.*) The fillet between the guttæ and the tenia in a Doric entablature. The depth of this fillet is much smaller in Roman than in Greek examples. *See* GUTTÆ: TRIGLYPH: ARCHITECTURE, ORDERS OF, *and* ENTABLATURE.

Capital of Triglyph (*Architect.*) The fillet immediately above and projecting over the triglyph in a Doric frieze. The projection of the capital beyond the triglyph is smaller in Greek than in Roman examples. *See* TRIGLYPH: ARCHITECTURE, ORDERS OF, *and* ENTABLATURE.

Capitulum (*Botany*). A compact form of inflorescence simulating a single flower. The "head" consists of a shortened axis (flat, convex, or concave) bearing many stalkless flowers (florets). The capitulum is invested by a number of scaly bracts.

Cap of Maintenance *or* **Dignity** (*Cost.*) A cap borne before the sovereigns of England at their coronation as one of the insignia of office. Such a cap is also borne before the mayors of certain cities.

Cap of Maintenance *or* **Dignity** (*Her.*) A cap used instead of a wreath to place a crest upon. Sometimes borne as a charge.

Cappagh-Brown (*Dec.*) Manganese brown: a pigment manufactured from bituminous earth, coloured by oxide of manganese and iron.

Capping (*Carp. and Join.*) The moulding on the top edge of a screen, the strings of stairs, etc.

—— (*Eng.*) The SHROUDING (*q.v.*) of gearing.

Capriccioso (*Music*). In a capricious manner.

Caprices (*Art*). Drawings or engravings, extravagant and fanciful in composition, such as those of Goya.

Capricorn, Tropic of. *See* TROPICS.

Caproic Acid (*Chem.*) $CH_3.(CH_2)_4.COOH$. A liquid boiling at 205°; it occurs combined with glycerine in butter; is a decomposition product of albumin; its amide is LEUCINE (*q.v.*)

Caps (*Typog.*) An abbreviation of the word "Capitals," usually indicated by three lines beneath the letters to be so printed, thus ≡. Small caps are indicated by two lines =.

Capsicum (*Botany*). *Capsicum minimum* (order, *Solanaceæ*). The dried ripe fruits form the well-known CHILLIES, and when ground form CAYENNE PEPPER.

Cap Spinning (*Woollen Manufac.*) In the cap spinning frame each spindle is mounted with a metal cap, and the threads whirl round the rim as they pass on to the bobbin.

Capstan (*Eng.*) A vertical rotating cylinder on which a rope is wound. The name often includes the machinery or engine by which the capstan is driven, as in the steam capstan of modern ships.

Capstan Headed Screw (*Eng.*) A screw with a large head, through which are drilled transverse holes, into which a small lever, or "tommy," is inserted to turn the screw.

Capstan Lathe (*Eng.*) A lathe with a rotating tool holder on the slide rest, by which various tools can be brought into action on the work in succession. It is also termed a TURRET LATHE.

Capsule (*Botany*). A class of fruit that opens by means of valves, pores, or slits to set free the numerous seeds.

Caraguata Fibre (*Botany*). *Eryngium pandanifolium* (order, *Umbelliferæ*). A fibre from the leaves is used under the trade name of Caraguata.

Caramel. *See* CANE SUGAR.

Carapace. The hard outer shell or exo-skeleton of certain animals; *e.g.* the shell of the tortoise.

Carat. (1) The standard of weight used by jewellers in weighing diamonds and other precious stones. It is equal to about $\frac{1}{150}$ of an ounce troy, or $3\frac{1}{6}$ grains. It is divided into 4 "carat grains." (2) The standard of fineness of gold. Pure gold is said to be "24 carat." STANDARD GOLD is "22 carat"—*i.e.* 24 parts by weight of the alloy contain 22 parts of pure gold. Similarly, 18 carat gold contains 18 parts of gold out of 24 parts by weight of the alloy, and so on for 15 carat, 12 carat, etc.

Caraway (*Botany*). *Carum carui* (order, *Umbelliferæ*). The so-called "seeds" are the mericarps (*q.v.*) or half fruits; they yield on distillation oil of caraway.

Carbamide (*Chem.*) The systematic name for UREA (*q.v.*); the name arises from urea being the diamide of carbonic acid.

$$OC\begin{matrix} \diagup OH \\ \diagdown OH \end{matrix} \qquad\qquad OC\begin{matrix} \diagup NH_2 \\ \diagdown NH_2 \end{matrix}$$

Carbonic acid. Carbamide.

Carbazole (*Chem.*) $\begin{matrix} C_6H_4 <> C_6H_4 \\ (1:2)\ NH\ (1:2) \end{matrix}$

Occurs in coal tar, and thus in crude anthracene; forms colourless plates, melting at 238°; readily sublimes. Is a feeble base like pyrrol, and also gives the pine-shaving reaction (*q.v.*). Nitric or nitrous acids give a blue colour to its solution in sulphuric acid.

Carbazotic Acid (*Chem.*) PICRIC ACID (*q.v.*)

Carbides (*Chem.*) Compounds formed by the union of carbon and a metal, directly or indirectly. Some of the important carbides are CALCIUM CARBIDE, CaC_2, obtained pure in golden yellow opaque crystals by heating pure lime and sugar charcoal in the electric furnace. The crude product is obtained from limestone and coal or coke. With water it gives acetylene (*q.v.*) Barium and strontium form similar compounds. ALUMINIUM CARBIDE, C_3Al_4: yellow transparent crystals obtained by heating carbon and aluminium, or calcium carbide and aluminium, in the electric furnace; it is decomposed by water, giving methane, CH_4. IRON CARBIDE, Fe_3C, has been obtained by electrolysis from steel; also in brilliant white crystals from Swedish iron by heating in a carbon crucible in the electric furnace, and subsequent purification of the product. Its formation and decomposition probably play an important part in the tempering of steel.

Carbine *or* **Carabine** (*Arms*). A firearm which came into use in the si[illegible]th century. It had a wheel-lock, and wide bor[illegible] was shorter than the ordinary hand gun. Generally used by cavalry.

Carbinol (*Chem.*) A name given to methyl alcohol in a system of nomenclature which names more complex alcohols as derivatives of methyl alcohol, the simplest possible alcohol. Thus, $\begin{array}{c} H \\ | \\ H—C—OH \\ \\ H \end{array}$ is methyl alcohol, and $\begin{array}{c} H \\ \\ CH_3—C—OH \\ | \\ C_2H_5 \end{array}$ would be called methyl ethyl carbinol.

Carbohydrates (*Chem.*) The carbohydrates are naturally occurring compounds containing six or a multiple of six carbon atoms, combined with hydrogen and oxygen, the proportions of these last two elements being the same as in water. Carbohydrates containing six carbon atoms are called MONOSES or MONOSACCHARIDES—examples are dextrose, lævulose, galactose; those containing twelve carbon atoms are called BIOSES or DISACCHARIDES—examples are cane sugar, lactose, maltose; those containing $(C_6)n$ are called POLYOSES or POLYSACCHARIDES—examples are starch and cellulose. The functions of carbohydrates in the animal system are the production of heat and energy. They are also a source of fat.

Carbolic Acid *or* **Phenol.** A powerful antiseptic, obtained from coal tar by distillation. It constitutes a great part of the tarry fluids on the market which are used for disinfecting purposes. The "carbolic

acid" powders and soaps are preparations containing the acid. Great care is necessary when using the acid, owing to it being so violent a poison. In chemical language it is termed PHENOL (*q.v.*)

Carbon (*Chem.*), C. Atomic weight, 12. An element met with in three allotropic forms—*viz.* DIAMOND (*q.v.*), GRAPHITE (*q.v.*), AMORPHOUS CARBON. CHARCOAL is one form of amorphous carbon, but it is not pure carbon; it contains ash and occluded gases. LAMP BLACK is another impure form, containing oil. Bone black or animal charcoal is another impure form (*see* BONE BLACK). Coke is another form containing the ash of the coal from which it was made. Pure amorphous carbon can be obtained by heating cane sugar out of air, then passing chlorine over the strongly heated residue, and allowing to cool in as good a vacuum as possible. The amorphous forms of carbon absorb gases, and take up colouring matter from many coloured solutions; they are powerful reducing agents—hence the use of coke in many metallurgical operations. Carbon is insoluble in all solvents, and is infusible; at the temperature of the electric arc the amorphous forms pass into graphite.

Carbonaceous Rocks (*Geol.*) Strata into whose composition carbonaceous matter of any kind enters. Besides the numerous varieties of coal may be mentioned OIL SHALE, BLACK BAND IRONSTONE, and even GRAPHITE SCHIST.

Carbonado (*Min.*) A very hard native form of carbon from Brazil. It is as hard as diamond. Used for truing-up emery wheels.

Carbonates (*Chem.*) The salts of carbonic acid. *See* CARBON DIOXI[illegible] As carbonic acid is dibasic, it gives rise to two [illegible]es of salts—the normal and acid carbonates (also called BICARBONATES) Thus:

$$\mathrm{O = C}\left\langle\begin{matrix}\mathrm{ON}\\ \mathrm{ONa}\end{matrix}\right. = \mathrm{Na_2CO_3}, \text{ normal sodium carbonate;}$$

$$\mathrm{O = C}\left\langle\begin{matrix}\mathrm{OH}\\ \mathrm{ONa}\end{matrix}\right. = \mathrm{NaHCO} \quad \text{acid sodium carbonate or sodium bicarbonate.}$$

The carbonates of sodium, potassium, and ammonium are soluble in water; the other normal carbonates are insoluble in water. Acid carbonates are soluble in water. Sodium and potassium normal carbonates are not decomposed on heating; they melt. Barium carbonate is decomposed with difficulty by heat; the remaining carbonates more or less readily. Many carbonates occur naturally. *See* CHALK, MARBLE, WITHERITE, STRONTIANITE, SPATHIC IRON ORE, CERUSSITE, CALAMINE, DOLOMITE, MAGNESITE, RHODOCROSITE, *etc.*

Carbon Black (*also called* **Gas Black**). A valuable series of pigments made principally from natural gas at Pittsburg and elsewhere in the United States. They are very fine, intensely black, and are used largely in the manufacture of printing inks, paints, etc.

Carbon Cores (*Moulding*). Cores (*q.v.*) of carbon are sometimes used in a mould where very heavy pressures are produced by the fluid metal during casting.

Carbon Dioxide *or* **Carbonic Acid Gas** (*Chem.*) CO_2. A colourless heavy gas having slight smell: water dissolves its own volume of the gas at ordinary temperature and pressure. Only substances with an extremely powerful affinity for oxygen, such as potassium and magnesium, can burn in the gas; for similar reasons, though it contains nearly 73 per cent. of oxygen, animals are asphyxiated in it. It is liquefied at the ordinary temperature under a pressure of 53 atmospheres, and liquid carbon dioxide is now used in icemaking, aërated water manufacture, etc. The gas is a product of combustion and respiration (*see* ATMOSPHERE), also of processes of fermentation and decay. It may be obtained by the action of an acid on a carbonate—*e.g.* hydrochloric acid and marble. When carbon dioxide is dissolved in water, part of the gas combines with the water to form the weak and unstable acid, carbonic acid, $\mathrm{O=C=O + H_2O = O=C}\left\langle\begin{matrix}\mathrm{OH}\\ \mathrm{OH}\end{matrix}\right.$. ORTHOCARBONIC ACID would have the formula $C(OH)_4$; it has not been prepared, but its organic salts are known—*e.g.* ethyl orthocarbonate, $C(OC_2H_5)_4$.

Carbon Dioxide in Air (*Hygiene*). The amount of this gas present in air averages about 4 parts in 10,000 parts of air. Its presence is due to respiration, artificial illumination, combustion, and manufacturing processes. Every individual exhales, while at rest, 0·6 of a cubic foot per hour. This amount increases from 0·9 during light work to 1·8 of a cubic foot during hard work. It is found that there is always a constant ratio between the quantity of carbon dioxide and other impurities present in the air. In estimating the purity of air, the amount of carbon dioxide is determined, since it furnishes a convenient index of general contamination. The action of plants on this gas is interesting. Every plant which contains chlorophyll has the power, under the influence of sunlight, of splitting up the gas into its component parts—namely, carbon and oxygen. The plant retains the carbon for its own use in tissue building, and liberates the oxygen.

Carbon Disulphide *or* **Bisulphide** (*Chem.*), CS_2. A colourless highly refracting liquid, having pleasant smell when perfectly pure, but ordinarily smelling like rotten cabbages. Boils at 46°; its vapour is very inflammable; insoluble in water. Largely used as a solvent for many organic substances, such as fats, oils, indiarubber, etc.; also readily dissolves sulphur and iodine. It is prepared by passing the vapour of sulphur over strongly heated carbon. It is the sulphur analogue of carbon dioxide; with alkalis it forms sulphocarbonates, R_2CS_3, analogous to the carbonates R_2CO_3.

Carbon Filters. *See* ANIMAL CHARCOAL.

Carbonic Acid. *See* CARBON DIOXIDE.

Carbonic Oxide. CARBON MONOXIDE (*q.v.*)

Carboniferous Rocks. *See* COAL.

Carboniferous System (*Geol.*) The group of strata which succeeds the Upper Old Red Sandstone (or its chronological equivalent) and lies beneath the base of the Lower New Red. It is so called because in Britain it affords coal seams of commercial value. It is primarily divided into an Upper and Lower subdivision, in both of which occur workable coals. Along with the Devonian Rocks and their equivalent, the Old Red Sandstones, it constitutes the DEUTEROZOIC ROCKS.

Carbon in Food (*Hygiene*). It is calculated that while doing a moderate day's work a man will eliminate from the lungs, as carbon dioxide, from 240 to 290 grammes of carbon. Other waste products, such as nitrogen, etc., are also eliminated from the body. To replace this loss, it is necessary to arrange a proper dietary. The proportion of carbon to nitrogen should be 16 to 1. *See also* FOODS, *under* SANITATION.

Carbonisation *or* **Carburisation** (1) The amount of carbon present in iron. It varies from a mere trace to very considerable amounts. *See* IRON, STEEL, *etc.* (2) The destructive distillation of organic matter (*e.g.* coal in gas manufacture).

Carbon Monoxide *or* **Carbonic Oxide** (*Chem.*), CO. A colourless gas having the same density as nitrogen; very slightly soluble in water. It is intensely poisonous, and, having no smell, is therefore a dangerous gas. It owes its poisonous action to its power of forming a more stable compound than oxygen does with the hæmoglobin of the blood, and thus causing asphyxia. It burns in oxygen with a blue flame, forming carbon dioxide. It is a reducing agent (*q.v.*) Unites with some metals, *e.g.* finely divided nickel, on heating, to form carbonyls, *e.g.* nickel carbonyl, $Ni(CO)_4$. It is produced whenever carbon is burnt in a restricted supply of oxygen; also on heating formic acid with sulphuric acid: oxalic acid with sulphuric acid (in this case equal volumes of this gas and carbon dioxide): potassium ferrocyanide with sulphuric acid. It may often be seen burning at the top of a bright fire, being formed from carbon dioxide produced during the combustion by union of the heated carbon dioxide and carbon, $CO_2 + C = 2CO$. The presence of 0.5 per cent. of this gas in air which is being inhaled produces poisonous symptoms, and 1 per cent. is rapidly fatal. Carbonic oxide is one of the constituents of coal gas (from 5·5 to 7 per cent.), and would therefore find its way into the air during leakage. Water gas (*q.v.*) also contains a large proportion of carbonic oxide, and as it has little or no smell, the use of water gas requires the exercise of great vigilance in preventing leakage, which is much less readily detected than in the case of coal gas.

Carbon Oxychloride (*Chem.*) *See* CARBONYL CHLORIDE.

Carbon Printing (*Photo.*) Paper is coated with gelatine containing potassium dichromate. When acted on by light, this becomes insoluble; while parts unacted on remain soluble, and may be washed away. By impregnating the gelatine with some suitable colouring matter a very fine permanent print can be made.

Carbonyl (*Chem.*) This name is given to the group $-CO-$ when in combination.

Carbonyl Chloride, Phosgene Gas, *or* **Carbon Oxychloride** (*Chem.*) A pungent-smelling gas easily condensed to a liquid boiling at 8°. It is obtained by union of equal volumes of carbon monoxide and chlorine in sunlight, and by oxidation of chloroform (*q.v.*) It is decomposed by water, $COCl_2 + H_2O = CO_2 + 2HCl$. Used as a reagent in organic chemistry. Thus with ammonia it gives urea; with zinc alkyls it gives ketones (*q.v.*); with benzene and aluminium chloride it gives diphenylketone. The graphic formula is $OC\!\!<^{Cl}_{Cl}$.

Carborundum. A Silicide of Carbon, SiC, used as an abrasive, harder than emery (which it resembles). Used also as an infusible coating for furnaces, etc. First manufactured by Acheson, at Niagara.

Carboxylic Acids (*Chem.*) The presence of the group carboxyl, $-C\!\!<^{O}_{OH}$, in an organic compound confers acid properties upon the compound; hence compounds containing this group are called carboxylic acids. Organic acids are known which do not contain this group, *e.g.* uric acid, picric acid.

Carbuncle (*Min.*) Red Garnet cut *en cabochon*. *See* CABOCHON.

Carburetter (*Motor Cars, Oil Engines*). The apparatus for turning oil into gas in petrol or other oil engines. The two main forms are SPRAY and SURFACE Carburetters. In the former a fine jet of oil is sprayed into a hot chamber, the supply being governed by a needle valve actuated by a hollow float, which rises and closes the valve when the supply of oil is too great. In surface carburetters a current of air is caused to bubble through the oil in a tank, producing evaporation at the surface of the oil and causing a mixture of air and explosive vapour to collect in the upper part of the tank. In both forms a further regulated supply of air can be caused to mix with the vapour produced in the carburetter, in order to obtain the explosive mixture which produces the greatest effect in the cylinder.

Carbylamines. Another name for the ISOCYANIDES (*q.v.*)

Carcanet (*Cost.*) A collar or necklace usually set with jewels.

Carcass (*Carp. and Join.*) (1) The structural part of a building—*i.e.* walls, naked floors, partitions, and roof. (2) The shell or outer part of any piece of joiner's or cabinetmaker's work.

Carchesium (*Pot.*) A beaker or cup used by the Greeks. It was slightly contracted in the middle, and had two handles extending from the base to the rim.

Cardamoms (*Bot.*) *Elettaria cardamomum* (order, *Zingiberaceæ*). The dried seeds are used in pharmacy and as a condiment.

Card Clothing (*Cotton Spinning*). A general term applied to the wire filleting on the cylinders, doffers, flats, or rollers of a carding engine. There are several gauges to suit Indian, American, or Egyptian cotton.

—— (*Woollen Manufac.*) Strips of leather or other suitable foundation into which wire teeth are inserted. The fineness of clothing—*i.e.* number of points per square inch—varies according to the position of the roller to which it is nailed in the carding machine, increasing towards the delivery end.

Carded Yarns (*Cotton Spinning*). Yarns which have only been carded. Not so valuable or so strong as COMBED YARNS (*q.v.*)

Cardew Voltmeter (*Elect.*) *See* VOLTMETERS.

Cardinal Planes of Lenses (*Light*). These are the PRINCIPAL, FOCAL, *and* SYMMETRIC PLANES (*q.v.*)

Cardinal Points (*Astron.*) The N., S., E., and W. points of the horizon. The N. and S. points are the points at which the meridian (*q.v.*) intersects the horizon (*q.v.*)

Cardinal Points of Lenses (*Light*). In dealing with thick lenses, or systems of lenses, the calculations are much simplified by the use of a system of points on the axis of the lens, termed the CARDINAL POINTS. *See* PRINCIPAL POINTS, PRINCIPAL FOCI, SYMMETRIC POINTS, *and* NODAL POINTS.

Carding (*Cotton Spinning*). A most important process, being the final stage at which cotton is cleaned for ordinary cotton yarns. A badly carded cotton will produce an inferior spun thread. Three types of carders are in use, *viz.*: (1) Revolving Flats; (2) Wellman's Stationary Flats; (3) Roller and Clearer Carder. The first is the English system; the second and third the American. The third is for coarse and waste spinning.

Carding (*Linen Manufac.*) In linen manufacture the flax is not carded as cotton is, but is hackled or combed. This takes out all the short fibres. The waste is called Tow, and is carded and spun, making a coarse description of yarn.

—— (*Textile Fabrics*). In general, the operation of separating and reblending textile fibres.

Carding Engine (*Textile Manufac.*) A machine consisting of several large cylinders and small rollers covered with card clothing (*q.v.*) The large cylinders, termed SWIFTS, convey the material forward. The medium rollers, or DOFFERS, remove it from the swifts. The small rollers, termed WORKERS and STRIPPERS, separate the felted meshes of fibres and also assist in reblending them in conjunction with the swifts.

Card Lacing (*Lace Manufac.*) The operation of attaching the Jacquard cards (*q.v.*) to each other in the order necessary to produce the required pattern.

Card Nippers (*Lace Manufac.*) A hand punch for use in correcting mistakes or making alterations in the cards.

Card Puncher (*Lace Manufac.*) The person who punches the holes necessary in the Jacquard cards to enable the pattern to be produced in machine-made lace.

Cards (*Lace Manufac., etc.*) *See* JACQUARD CARDS.

Card Wire (*Eng.*) A brush of fine steel wire, used by fitters for cleaning out file teeth.

Carmagnole (*Cost.*) The dress affected by the Jacobins during the French Revolution of 1789. It consisted of a red cap, blouse, and a girdle of blue, white, and red.

Carmine (*Dec.*) A beautiful bright red pigment made by precipitating colouring matter obtained from COCHINEAL (*q.v.*), with a base such as alumina. It works well in oil and water, but soon fades on exposure to light. The colouring matter is CARMINIC ACID, a complex organic compound.

Carnallite (*Min.*) A chloride of magnesium and potassium, $MgCl_2 . KCl . 6H_2O$; Magnesium chloride = 34·2, potassium chloride = 26·88, water = 38·92. Massive, usually pinkish from impurities of ferric oxide. It is very deliquescent and strongly phosphorescent. It occurs in considerable quantity at Stassfurt in Saxony, where it is largely worked. It is used in glass manufacture, etc., as a source of potassium.

Carnation (*Paint.*) The various tones of pink used in painting flesh. It also signifies those parts of the body that are drawn naked.

Carnauba Wax. The wax deposited upon the leaves of the Wax Palm (*Copernicia cerifera*), indigenous to Brazil. The crude wax is obtained by boiling the leaves; it is of a dirty yellowish colour, very hard and brittle, being readily reduced, by pressure, to powder. Used in admixture with the softer waxes, such as paraffin, for making candles and wax polishes (*q.v.*)

Carnelian (*Min.*) A red translucent CHALCEDONY (*q.v.*), used largely for beads and seals. When found, the colour of the masses is very dark, but much of the colour is discharged on roasting.

Carnot's Cycle (*Heat*). The set of operations in a theoretically perfect HEAT ENGINE (*q.v.*) The working substance in the cylinder goes through the four following processes in succession: (1) Adiabatic Compression, (2) Isothermal Expansion, (3) Adiabatic Expansion, (4) Isothermal Compression. If these conditions could be realised in a steam or gas engine, the highest possible efficiency would be attained. *See* INDICATORS *and* INDICATOR DIAGRAMS.

Carpentry. The art of constructing and erecting the structural woodwork of a building, *i.e.* beams, joists, partitions, roofs, etc., as distinguished from JOINERY, which deals with the smaller and more finished parts, such as doors, windows, and staircases. As carpenters' work requires to be very strong and reliable, it should always be constructed on thoroughly scientific principles, and it is therefore erroneous to describe it as "rough" woodwork.

Carpentum (*Archæol.*) An antique two-wheeled carriage, protected by an awning and curtains. Used by Roman ladies at festal processions. Carpenta were also used by the Gauls and Britons.

Carpet. Woven or felt floor covering. Woven carpets are of two great types: (1) An ordinary woven fabric, *e.g.* Scotch or Kidder carpets; (2) Pile woven fabrics, *e.g.* Brussels, Axminster, Persian, Smyrna, etc.

Carrageen Moss (*Botany*). *Chondrus crispus* (class, *Rhodophyceæ*). This red seaweed is used in the preparation of a nutritive jelly.

Carrara Marble. A metamorphosed limestone of sedimentary origin. It is of exceptional purity and uniformity of composition. Usually regarded as a member of the Trias (*q.v.*) It is chiefly obtained from the quarries at Carrara, in Italy, and is much used for sculpture.

Carriage (*Carp. and Join.*) The rough inclined timber supporting the steps of wooden stairs.

—— (*Lace Manufac.*) A thin flat piece of steel, roughly triangular in shape, with a segmental base and a circular hole central with the body of metal forming the receptacle containing the brass bobbins. The two combined form a SHUTTLE.

Carriage Gain (*Cotton Spinning*). *See* PATCHING.

Carrier (*Eng.*) A holder which can be attached to a round rod, etc., when being turned in the lathe, to enable the driving chuck to rotate the work between the centres.

—— (*Optical Lantern*). A frame of convenient form which holds the small unframed slides which are usually made at the present time; the carrier remains fixed in the lantern, and enables the slides to be placed in position accurately and quickly.

Carrollite (*Min.*) A copper and cobalt sulphide, $CuS . Co_2 S_3$. Isometric. This rare mineral is chiefly of interest from the recent discovery in it of traces of RADIUM. It is found in the United States.

Carte de Visite (*Photo.*) The small size of print commonly used for portraits; it is about $3\frac{1}{2}$ in. by $2\frac{1}{4}$ in., *i.e.* about half the size of a QUARTER PLATE (*q.v.*)

Cartilage (*Zoology*). An elastic tissue which precedes bone as the constituent of the skeleton. It also forms efficient pads between the various bones. Cartilage consists of a matrix of CHONDRIN, containing cells and, in some cases, fibres.

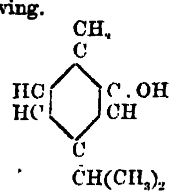
Cartisane. A small piece of parchment placed under embroideries to give relief.

Cartoon (*Art*). (1) A study or design made on paper for a painting of the same size which is to be executed in fresco or oil, especially the former, the design being traced through upon the fresh plaster of the wall. Cartoons are also executed in colours for designs in tapestry, mosaic, stained glass, etc. The cartoons of Raphael are well known examples. (2) An illustration in a newspaper or periodical relating to some current topic or event.

Cartouch *or* **Cartouche** (*Architect., etc.*) (1) A modillion in an internal cornice. (2) Also used to denote a shield-shaped, scroll-shaped, or oval ornament. (3) The oval used in Egyptian hieroglyphics to enclose certain characters expressing the names or titles of divinities and kings.

Cartridge Paper. Paper originally used in the manufacture of cartridges. It is cheap and useful for rough drawing.

Carvacrol.



Is an oil occurring in certain essential oils; boils at 236°. Obtained by heating camphor with iodine.

Carving. This term is now usually restricted to work executed in wood and ivory, the term "Sculpture" being applied to carving in stone, and "Chasing" to metal work. Carving was naturally practised at a date anterior to sculpture, and in early examples of sculptured stone the influence that wood-carving exercised on the sculptor is easily discernible. The Greeks excelled in ivory-carving, and some chryselephantine statues (*q.v.*) of marvellous beauty were executed by Pheidias. During the Gothic period (twelfth to sixteenth century) wood-carving reached a high standard, especially as regards the interior decoration of churches. The most celebrated wood-carver this country has produced is Grinling Gibbons (1648—1720), who, in addition to many other notable examples, executed the stalls of St. Paul's Cathedral. Efforts are being made at most art schools to revive this art, which, like so many other valuable and interesting handicrafts, has for several years past undeservedly suffered in the competition with work executed by machinery.

CARYATID. FROM ERECTHEUM.

Caryatid (*Architect.*) A carved figure of a female used as a column, as in the portico of the Erectheum. *See* ATLANTES.

Cascara Sagrada (*Botany*). *Rhamnus purshiana* (order, *Rhamnaceæ*). The dried bark is the source of the purgative drug of this name.

Cascarilla (*Botany*). *Croton Cascarilla* (order, *Euphorbiaceæ*). The dried bark is used in medicine as an aromatic tonic.

Case (*Typog.*) The receptacle from which type is gathered for composing. There is an upper and a lower case. The former, divided into various compartments, contains the capitals and the accented and dotted letters; the latter, likewise divided, contains the small letters, spaces, etc.

——, **Casework** (*Bind.*) Covers, cloth bound or otherwise, prepared separately from the book, which is afterwards fastened into them.

Cased Frame (*Carp. and Join.*) A window frame having the sashes hung with cords.

Case Hardening (*Eng.*) The production of a thin layer of steel on the surface of iron bodies by heating them to a bright red in contact with carbonaceous matter.

Casein (*Chem.*) The essential and characteristic albumin of milk. It is composed of carbon, hydrogen, nitrogen, oxygen, sulphur, phosphorus. It is an acid: insoluble in water, but its salts are readily soluble, and it is present in milk as its neutral calcium salt. It is precipitated from solutions of its salts by acids, even by carbonic acid; it may also be salted out by common salt and magnesium sulphate. The food Plasmon is said to be the sodium salt of casein. During the last few years casein has been largely used as a binding material in the manufacture of washable distemper or water paints (*q.v.*)

Casemate *or* **Casement** (*Architect.*) A large hollow moulding used in Gothic architecture, particularly in the Perpendicular style.

—— (*Carp. and Join.*) A window consisting of glazed doors hung to a solid frame, instead of sliding sashes.

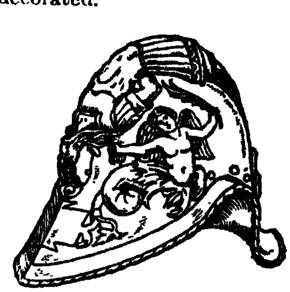
Cashmere. Soft, fine, silky fibre forming part of the fleece of the Cashmere goat of Thibet.

—— (*Woollen Manufac.*) Fine twill dress stuffs made of worsted yarns.

Cashmere Goat. *Capra hircus* (family, *Bovidæ*). A small variety of goat having a thick coat of wool beneath the long silky hair.

Casket *or* **Casquet.** A small coffer or box, generally made of some rare or precious material, wood, or metal, often highly decorated.

Casque (*Armour*). A term applied to all kinds of helmets. More precisely a species of helmet first worn in the reign of Henry VIII. It was intended more for parade than protection, and was, generally, elaborately ornamented. It had no visor.



CASQUE, MILANESE, c. 1540. BARON DE COSSON COLLECTION.

Casquetel (*Arm.*) A small helmet or steel cap without visor, but having a projecting umbril, and flexible plates to cover the neck.

Cassel Yellow. Oxychloride of lead — $PbCl_2 7PbO$.

Cassia Bark (*Botany*). *Cinnamomum cassia* (order, *Lauraceæ*). The bark of this plant is a frequent adulterant of cinnamon.

Cassiterite (*Min.*) An oxide of tin, SnO_2; Tin = 78·38, oxygen = 21·62 per cent. Often called tin stone. It crystallises in tetragonal prisms. Often twinned (*q.v.*) at an obtuse angle (geniculate twins). It is the most important ore of tin. The varieties WOOD TIN and TOAD'S EYE TIN are those which show a concentric banding. STREAM TIN is water-worn Cassiterite. It occurs in Cornwall, Devon, Saxony, Straits of Malacca, United States, Australia.

Cassock (*Cost.*) Originally almost any kind of long loose coat worn during the seventeenth and eighteenth centuries. A long, close-fitting garment worn by the Anglican clergy, originally under the gown; at the present time under the surplice. Also worn by any ecclesiastical official, cleric or layman.

Cast (*Eng., etc.*) (1) A twist in timber due to drying. (2) Applied to material suitable for casting (*q.v.*)

—— (*Sculp.*) (1) The name applied to a facsimile of an original piece of sculpture. It is generally executed in plaster, cast in a mould. The usual method of reproduction is as follows: The object of which a copy is required is first smeared with boiled soft soap; it is then covered, in sections, either with molten wax or wet plaster of Paris, until a mould of the whole has been obtained. This piece-mould is fitted together, and plaster and water are run into it. When the mould is removed there remains a facsimile of the original in plaster. (2) The name is sometimes applied to the mould or reversed impression in which the cast is made.

—— (*from Nature*). This may be taken either from a living or a dead body, and may be a cast of the entire frame or any portion, such as a hand or foot. The same process is followed substantially as in making a cast from sculpture.

Cast Holes (*Eng.*) Holes are cast to save metal or the expense of drilling; they are not accurate in size or position, and require careful finishing in exact work.

Casting (*Foundry*). (1) The metal object produced by pouring molten metal into a mould of requisite shape. (2) The operation of producing the above.

Casting Ladle (*Foundry*). The large receptacle used for carrying and pouring out the molten metal.

Casting On (*Foundry*). *See* BURNING ON.

Casting Upright, on End (*Foundry*). The fixing of a long mould in a vertical position (usually in a pit); the metal is then often poured down a long tube or channel in the sand, and enters the mould at the bottom. This produces a sound casting, as gas bubbles, etc., are driven out at the top of the mould; scoriæ, etc., collect in a HEAD (*q.v.*)

Cast Iron. *See* IRON.

Cast Iron Pipe (*Eng.*) Used for water and gas mains, and for steam pipes when the pressure is not too great; the cheapest form of iron pipe.

Castle. Generally a series of strong buildings connected together and originally intended to serve as a fortress. Such fortresses were chiefly the outgrowth of feudalism, and until after the Norman Conquest were seldom to be found in England. The thirteenth century marked the greatest advance in the fortification of castles. The strongest part of the mediæval castle was the donjon or keep, intended to form the last retreat of the garrison.

Castoreum. A waxy substance from the anal glands of the beaver, *Castor canadensis* (family, *Castoridæ*). Large quantities are used in medicine on the Continent.

Castor Oil. Oil obtained from the seeds of *Ricinus communis* (order, *Euphorbiaceæ*), a plant cultivated in India, the United States, Java, and elsewhere. The refined oil is almost colourless, very viscid; thickens and becomes rancid on exposure to the air, but does not dry. The best quality is produced by pressure of the bruised seed, is used for medicinal purposes, and is known as "cold drawn." Second and third qualities are obtained by heating the same seeds and again pressing them. These qualities are used in the manufacture of lubricants and for dressing leather, particularly morocco and chamois leathers. Castor oil is expressed in several parts of England from imported seed. Sp. gr. 0·960 to 0·966 at 60° F.

Casts (*Geol.*) Properly speaking, this term should be restricted to such cases as those where an alien substance has filled a cavity or mould formed by the removal of some pre-existent rock, mineral, or fossil, and thus imitated its form; but in practice the term is often applied to the mould itself.

Cast Steel (*Eng.*) Ingots of steel obtained by breaking up and melting BLISTER STEEL in a crucible. *See* STEEL.

Catacomb. A subterranean place for burial of the dead, consisting of galleries or passages, the bodies being deposited in recesses called *loculi*, excavated in the sides. Applied originally to the cemetery under the Basilica of St. Sebastian, Rome; it is now used in respect of all of the many subterranean places of sepulture in or near Rome, as well as those of Cairo, Naples, Paris, etc.

Catafalque. A decorated platform on which a coffin is placed in church during a funeral service.

Catalysis *and* **Catalytic Action** (*Chem.*) The speed of certain reactions is considerably changed by the introduction of a third substance, which itself remains unchanged at the end of the reaction. The action exercised by such a substance is called a catalytic action or catalysis, and the substance is called a catalytic agent or catalysor. An example of such a change is the conversion of starch into dextrose and dextrine by water; by heating with water alone the change is very slow, but in presence of a little sulphuric acid the speed is enormously increased. Other examples are the conversion of cane sugar to dextrose and lævulose by a dilute acid; the hydrolysis of esters by the same means; the union of sulphur dioxide and oxygen in presence of platinum black; the decomposition of hydrogen peroxide also, by finely divided platinum. The amount of catalytic action is, up to certain limits, proportional to the amount of catalysor present, and it is also dependent on temperature. *See also* ENZYMES.

Catch Bar (*Lace Manufac.*) An approximately square iron bar long enough to extend over the whole width occupied by the carriages. A brass blade attached to the bar engages with certain projections on the carriages, and moves them all simultaneously.

Catch Plate (*Eng.*) A small face plate (*q.v.*) for a lathe: it carries a projecting pin, which engages with a carrier fixed on the end of a bar, etc., which is being turned in the lathe.

Catchword (*Typog.*) The first word of the following page of a book, inserted at right-hand lower corner in the "whiteline." Not generally used now except in encyclopædias and dictionaries.

Catechol, Pyrocatechin, Orthodihydroxybenzene. $C_6H_4(OH)_2$. White crystalline solid, soluble in water; melts at 104°. Gives, like all orthodihydroxybenzene derivatives, a green colour with ferric chloride; it occurs in beechwood tar and catechu (*q.v.*) Obtained by heating protocatechuic acid (*q.v.*), and by heating either 1 : 2 bromphenol or 1 : 2 phenolsulphonic acid with caustic potash.

Catechu. An extract of the leaves and young shoots of *Uncaria Gambia* (Singapore, etc.) and from *Acacia catechu.* The juice is evaporated and is made into cubes which have a reddish-brown colour; it contains catechu-tannic acid, catechin, and catechol. On distillation it gives catechol. Used in dyeing and calico printing, and as an astringent in medicine. *See also* DYES AND DYEING.

Catenary. The curve which a heavy cord or chain assumes when suspended between two points.

Cateract (*Eng.*) A hydraulic arrangement for regulating the valves in Cornish pumping engines; very little used now.

Catgut. Tough strings made from the prepared intestines of sheep. A strong driving-cord for machinery is made from the intestines of horses and asses *See also* WASTE PRODUCTS.

Cathedral Glass. A name commonly applied in the building trades to combinations of coloured glass.

Catherine Wheel Window (*Architect.*) *See* ROSE WINDOW.

Cathetometer (*Physics*). A microscope or telescope mounted horizontally on a vertical stand. It can be either raised or lowered, but it always remains horizontal. The rise or fall can be accurately read on a finely divided scale, thereby giving measurements of vertical heights which do not exceed the range of the scale of the instrument.

Cathode *or* **Kathode** (*Elect.*) The conductor, or ELECTRODE, by which an electric current leaves a liquid or gas; it is usually a piece of carbon or metal in the shape of a flat plate, disc, rod, etc. *Cf.* ANODE.

Cat's Eye (*Min.*) A variety of QUARTZ (*q.v.*) showing a fine fibrous structure, so that when cut *en cabochon* it gives a sudden flash of light in certain directions. Fine examples come from Ceylon and Malabar. *See also* PRECIOUS STONES.

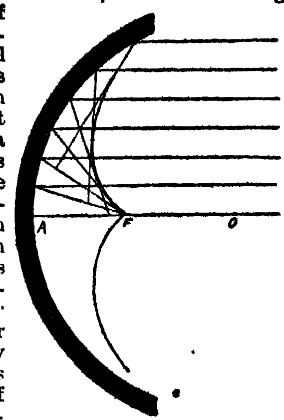
Cat's Head (*Architect.*) A Norman ornament, resembling the beakhead, but having a protruding tongue instead of a beak. *See* BEAKHEAD.

Caulicoli (*Architect.*) The eight stalks which spring from the upper row of leaves in a Roman Corinthian capital. This term is also used to denote either the volutes in which these eight stalks terminate, or the stalks and scrolls together. It is also written Cauliculus, Caulicolus, and Caulecole. *See* ARCHITECTURE, ORDERS OF, *and* CORINTHIAN.

Caulk *or* **Calk** (*Plumb.*) To run lead into the socket of an iron pipe and hammer it in with a caulking chisel. *See also* CALKING.

Causia (*Archæol.*) A broad-brimmed hat worn by the ancient Romans. Originally worn by the Macedonian kings.

Caustic (*Light*). A curved line or surface produced by the intersection of rays from reflecting or refracting surfaces of certain forms. For example, in a spherical mirror the reflected rays do not pass through any one focal point, but touch a curve with a "cusp," whose point is on the axis of the mirror. The caustic produced by the reflection of parallel rays from a spherical mirror is shown in the illustration. The rays near the axis of the mirror OA intersect at or very near a point F, which is the principal focus of the mirror. The distance AF is half the distance AO, which is the radius of curvature of the mirror.



CAUSTIC CURVE.

Caustic Alkali. *See* ALKALI.

Causticising Pan (*Paper Manufac.*) A cylindrical vessel, usually fitted with agitators, in which carbonate of soda is converted into caustic soda.

Caustic Potash. *See* ALKALI.

Caustic Soda. *See* ALKALI.

Cave Breccias (*Geol.*) A cemented mass of angular fragments of any kind (not usually limestone or bone) which have fallen into a subterranean cave or a fissure, from above, or have been washed into it by torrents. It may be of any age, but it is usually of comparatively recent origin.

Cave Earth (*Geol.*) A general term applied to the loam, sand, or clay which has found its way into caves (usually in those of limestone districts) by the action of running water.

Cavendish Experiment (*Physics*). An experiment of Henry Cavendish for finding the absolute force between two attracting masses. From this absolute force it is possible to calculate the mass of the earth. Cavendish found it to be 5·448 times the mass of an equal volume of water. This experiment has been repeated by later observers with different forms of apparatus, and the latest results obtained show that the actual density of the earth is about 5·527 times that of water.

Cavern (*Geol.*) Generally used as a synonym for cave; but it would be conducive to clearness if the term cave were restricted in geological phraseology to the subterranean chambers formed by the solvent action of waters upon limestone, and if the name cavern were used for the natural underground excavations, such as those which are produced by the mechanical action of the sea. The term grotto might in that case be employed for the rock cavities often left in lava beds.

Cavetto (*Architect.*) A hollow moulding. In Roman work its section is a quarter circle; a Grecian cavetto has a more graceful contour.


CAVETTO.

Caviare. A Russian food preparation made from the roe of the sturgeon, *Accipenser sturio* (sub-order, *Chondrostei*).

Cavo-Relievo (*Architect.*) Sculpture, in which the highest part of the relief is level with the general surface of the stone; much used in Egyptian sculpture. *See* BASSO-RELIEVO, ALTO-RELIEVO, MEZZO-RELIEVO, *and* INTAGLIO.

Cawk (*Min.*) A miner's term for BARYTES (*q.v.*)

Caxton. Any book printed by William Caxton, England's first printer, is known as a "Caxton." All his productions are in black letter, and were issued between the years 1474 and 1491. Although a most prolific printer, copies of his publications are now both rare and valuable. While many of his later publications have disappeared altogether, several copies of the first edition of his earliest and best known books, *The Recuyell of the Historyes of Troye* and *The Game and Playe of the Chesse* are still extant. His greatest work, *The Golden Legend*, published about 1484, was profusely illustrated with wood cuts. Of the first edition of this work many copies remain. The finest collections of "Caxtons" are those in the British Museum and the Rylands Library, Manchester.

Cayenne Pepper. *See* CAPSICUM.

Cd (*Chem.*) Symbol for CADMIUM (*q.v.*)

Ce (*Chem.*) Symbol for CERIUM (*q.v.*)

Cedar. *See* WOODS.

Cedar Wood Oil. *Cedrus*, several species (order, *Coniferæ*). An oil obtained by distillation from cedar wood shavings.

Ceiling Joists (*Carp.*) The timbers (below the floor joists) to which the laths are nailed. *See also* FLOORS.

Celadon (*Pot.*) Porcelain in which the colour is mixed with the glaze and burnt in at the first firing.

Celebe (*Pot.*) A Greek vase in form resembling an urn and having two handles.

Celestial Equator (*Astron.*) The GREAT CIRCLE (*q.v.*) on the celestial sphere, whose poles are the celestial poles.

Celestial Poles (*Astron.*) The two points about which the celestial sphere appears to revolve.

Celestial Sphere (*Astron.*) An imaginary hollow sphere, whose centre is at the eye of the observer. A line drawn from the centre to each of the heavenly bodies cuts this sphere at a point which is the apparent position of the body in question.

Celestine (*Min.*) Strontium sulphate, $SrSO_4$. Strontia = 56·4, sulphuric acid = 43·6 per cent. It crystallises in rhombic tables. The crystals are colourless, or more often pale blue, very brittle. It is found frequently in association with gypsum, rock salt, and sulphur. Bristol and Lake Huron are two of the principal localities.

Cell *or* **Cella** (*Architect.*) The space enclosed within the walls of a Grecian temple. Sometimes this space was undivided, and formed the principal chamber, or NAOS, in which was placed the statue of the deity. In other cases the cella was divided into two portions—the larger portion, the NAOS, in the front, and a smaller chamber, called the OPISTHODOMUS, used as a treasury, at the back. The naos was approached through a columnar porch, the pronaos; the opisthodomus through the rear porch, the POSTICUM or EPINAOS. The term cell is also used to denote the filling in between the ribs of Gothic vaulting. *See* SEVERIES, NAVE, *and* ANTA.

Cell *or* **Cella** (*Biology*). The unit of an animal or plant organism. It consists of a mass of protoplasm containing a nucleus, and may, or may not, have a cell wall.

Cellar Dwellings (*Hygiene*). Use of a cellar as a dwelling is absolutely prohibited by the Public Health Acts. A cellar may not be occupied at all unless it accords with the requirements laid down in the Acts. These relate to height, drainage, sanitary accommodation, ventilation, light, etc.

Cells, Primary. The primary cell is a means of obtaining electrical energy by the actual consumption of some metallic element, usually zinc, which is turned into its sulphate or some other compound. The cell cannot then be used again without introducing an entirely fresh material, thereby differing from the storage cell or accumulator (*q.v.*) It may be compared to a kind of furnace, in which the zinc is the fuel. The essential parts of a cell consist of the negative plate, which, as mentioned above, is almost invariably zinc; a positive plate, which is commonly platinum, copper, or carbon; an exciting liquid, which acts chemically on the zinc; and finally some material which may be termed the "depolariser." The function of the latter body is to furnish a regular supply of oxygen in the neighbourhood of the positive plate, and thereby to destroy the free hydrogen which would be liberated there, and which if allowed to accumulate would stop the action of the cell. The main essentials of a good cell are as follows: (1) The electromotive force should be constant; (2) The internal resistance of the cell should be as small as possible; (3) The cell must be free from polarisation; (4) The chemical action in the cell should cease when the current is no longer flowing. The first condition (electromotive force) depends entirely upon the chemical nature of the materials employed, and is always constant so long as the nature and condition of the materials are the same; it is perfectly independent of the size of the cell or distances between the plates. The internal resistance of the cell, however, depends very largely upon its size and the distance between the plates, and can be diminished by making the plates large and bringing them close together. Freedom from polarisation depends (in the majority of cases) upon a sufficient and regular supply of oxygen being furnished by the polarising agent. The last condition is one of difficulty of attainment in most classes of cell; and in the more active forms of primary cell it is necessary to withdraw one or both plates from the fluid. The chief forms of cell in common use are as follows: (1) *Dichromate Cell:* This consists essentially of a plate of zinc and a plate of carbon, the exciting fluid being dilute sulphuric acid, and the depolariser a solution of potassium dichromate which is mixed with the acid. This mixture is very active, and it is absolutely necessary that the plates should be withdrawn when the cell is not in use. Instead of potassium dichromate, chromic anhydride (CrO_3) or potassium chromate (K_2CrO_4) may be used. An improvement may be made by putting the carbon plate and the potassium dichromate solution into a porous pot, leaving the zinc in the dilute sulphuric acid: in most cases, however, the fluids are mixed. The electromotive force of this cell is about two volts. (2) *Grove's Cell:* The positive plate is a piece of platinum foil, which is immersed in a depolariser consisting of strong nitric acid in a porous pot; the negative plate is zinc in dilute sulphuric acid. This is a very good cell; but the use of nitric acid is

somewhat objectionable both from the dangers of handling the acid itself, and from the corrosive fumes of the oxides of nitrogen which are given off as the acid parts with a portion of its oxygen. For this reason a Grove's battery will require to be kept under a hood with a steady draught to carry off the fumes. The electromotive force is about 1·9 volts. (3) *Bunsen's Cell:* This resembles Grove's cell in all respects but one, *viz.* that the positive plate is a rod of carbon instead of platinum foil. Its electromotive force and other properties are much the same as those of Grove's cell. (4) *Daniell's Cell:* The negative plate is zinc in sulphuric acid, as before. The positive plate is copper in a saturated solution of copper sulphate, the two fluids being separated by a porous pot. In this case no hydrogen is actually set free, but the copper sulphate is acted upon by the nascent hydrogen, metallic copper being formed, and deposited upon the copper plate. This deposition of copper does not alter the nature of the positive plate, and therefore there is no alteration in the electromotive force. The cell yields an electromotive force of 1·07 volts, and is remarkably constant in its action; on this account it is a very great deal used in telegraphic work. (5) *Leclanché Cell:* The negative plate is zinc acted on by a solution of ammonium chloride. The positive plate is a rod of carbon packed in a mass of manganese dioxide, which furnishes a supply of oxygen, and therefore acts as a depolariser. When this cell has been running for a very short time, it becomes polarised, and it is some time before the manganese dioxide can destroy this polarisation. If, however, the cell be given a comparatively long rest between short intervals of use, it easily recovers, and will last a very long time with no further attention than the addition of a little water. It is chiefly used for intermittent work, such as the ringing of electric bells. (6) *Dry Cells:* The so-called dry cells really consist of some form of Leclanché cell, in which the exciting fluid is mixed with some material to make it into a kind of damp paste, as a perfectly dry cell would be useless. There are many modern forms of dry cell, most of which have for their object the reduction of the internal resistance, which naturally tends to become very great when the cell no longer contains a mass of fluid. (7) *Lalande's Cell:* This is a zinc and copper cell, but the polariser consists of a mass of copper oxide surrounding the copper. The zinc is acted upon by a solution of caustic potash, KOH, in which the metal dissolves. It has a low electromotive force, about ·8 volts, but is a reliable and constant cell. In addition to the above, certain primary cells are constructed for the purpose of serving simply as a standard of electromotive force. In all these the object is not to obtain a current at all, but to ensure that the voltage shall be as constant as possible. Clark's cell (*q.v.*) is one of the best known and most reliable forms.

Celluloid. Is a mixture of camphor and pyroxylin (a mixture of the tetranitrate and pentanitrate of cellulose). The camphor is dissolved in alcohol, and the pyroxylin added, and the mass worked together between rollers; then warm-pressed. Celluloid is highly inflammable, but not explosive; it may be coloured by adding the required colour before working up the mixture. Largely used as a substitute for ivory, horn, and bone in combs, various ornaments, etc.

Cellulose, $(C_6H_{10}O_5)n$. Examples of very nearly pure cellulose are good Swedish filter paper; well washed linen; purified cotton wool. It has an organised structure; its chemical constitution is unknown. A solution of copper hydroxide in ammonia (Schweitzer's reagent) dissolves cellulose, and a hydrated cellulose is obtained by evaporating the solution or precipitating it by salt or acids. This fact has received several important technical applications, as in papermaking, making artificial silk (lustracellulose), making boards which are used in building. Zinc chloride and alkaline sulphocarbonates also dissolve cellulose; the solution in the latter case is called VISCOSE. Both these solutions are used in making artificial silk (lustracellulose). Strong solutions of caustic soda, (NaOH), act on cellulose, a compound, $(C_{12}H_{20}O_{10}Na_2O)n$, being formed which, on washing, gives a hydrated cellulose. When cotton goods are treated in this way, and tightly stretched to prevent shrinkage, the cotton is MERCERISED—it becomes lustrous and dyes better, especially with turkey red. The action of a mixture of nitric and sulphuric acids is very varied. *See* COLLODION, GUNCOTTON, PYROXYLIN, CELLULOID. When filter paper is dipped in sulphuric or nitric acid of proper strength, and then withdrawn, it becomes toughened; with a rather stronger sulphuric acid, unsized paper gives PARCHMENT PAPER; with concentrated sulphuric acid the cellulose dissolves—on dilution of the product and boiling, glucose (a sugar) is produced. This is the origin of the popular expression "making sugar from rags." Bleaching powder solution in presence of air, boiling dilute nitric acid, ferric compounds in presence of light oxidise cellulose—the last producing the well known "iron stain" on linen. Cellulose is not digested when taken with food; hence the necessity of cooking starchy foods, the cell walls of which, consisting of cellulose, are burst by the process of cooking.

Celsius' Scale (*Heat*). The CENTIGRADE SCALE (*q.v.*)

Celt (*Archæol.*) An implement of stone, bronze, or iron, with chisel-shaped edge, found among the remains of prehistoric man. A SOCKET or POT CELT is one with a hole at the end for receiving a handle.

Cement (*Build.*) *See* CEMENTS.

Cementation (*Metallurgy*). The older process for the manufacture of steel. Bars of wrought iron are packed in firebrick boxes or troughs, termed CONVERTING POTS, along with charcoal powder, and heated in a furnace for some days. A part of the carbon is gradually absorbed by the iron, converting it into steel. The process is now largely superseded by the BESSEMER PROCESS (*q.v.*) *See also* STEEL.

Cement Fillet (*Build.*) A strip of cement put in the angle where the roof joins the wall, instead of lead flashing; it serves to make a watertight joint between the roof and the wall.

Cementing Materials in Rocks (*Geol.*) As a rule the cement which unites the particles of rocks of clastic origin is silica, lime, or iron; but various other mineral substances occasionally occur along with these, or may occur quite alone. In nearly all cases the cementing matter has been carried in by the action of percolating waters.

Cement Joggle (*Build.*) A V-shaped recess cut in the vertical joints of stonework, and filled in with cement to strengthen the joint; it serves as a kind of connecting piece or DOWELL.

Cements (*Build.*) Of these, by far the most important is ordinary mortar. This is defined in the building rules of the London County Council as

consisting of one part of freshly burned lime, mixed with three parts of clean sharp sand free from earthy matter. Lime itself is produced by heating chalk or limestone, which is a more or less pure form of calcium carbonate. On heating, calcium oxide, CaO, is left behind. When this is "slaked" or treated with water, a portion of the water becomes chemically combined with it, forming calcium hydrate, $Ca(OH)_2$. The setting of the mortar in the masonry appears to be due mainly to the absorption of carbonic acid gas from the air, which converts the calcium hydrate into calcium carbonate; but there is no doubt that the silica in the sand also enters into some kind of combination, helping to produce a hard mass which adheres firmly to the stones or bricks between which the mortar is placed. *Hydraulic Lime:* If a limestone contain a certain amount of clay, or material resembling clay in chemical composition, the lime made from it has the peculiar property of being able to harden under water to a greater or less extent; such lime is termed HYDRAULIC LIME. Its action appears to be due to the formation of a compound between the lime and the silica contained in the clay, and this hardens independently of any absorption of carbonic acid, and therefore does not require exposure to the air. The same property is, however, possessed in a greater degree by the following cements. *Portland Cement:* A mixture of one part of lime and two parts of clay is thoroughly incorporated by grinding together. It is then dried in the air and cut into blocks, which are placed in a suitable kiln and burned at a glowing heat. Care must be taken in this operation that the materials are not actually melted, as, if they were, a glassy substance would be produced, which would be quite valueless. After burning, the substance is ground to an extremely fine powder. This part of the process is very important to the successful action of the cement, and it may be noted that the greater part of the product from the grinding mill ought to be sufficiently finely ground to pass through a sieve with seventy-six meshes per linear inch. Portland cement may be mixed with a considerable quantity of sharp sand, and forms an extremely durable and strong cement. Portland cement is frequently adulterated by the addition of foreign materials, of which the chief are gypsum, slag, slate, and unburned limestone. These have a very deleterious effect on the strength of the cement. *Roman Cement:* A cement made from material somewhat inferior to Portland. It is about a third of the strength of Portland cement, and is about two-thirds of the price. Its principal advantage is that it sets more quickly. *Plaster of Paris:* This consists of gypsum which has been heated to drive off its water of hydration. It gives a beautiful white and smooth surface, but has very little strength. *Keen's Cement:* This consists of burned gypsum, which has been heated with a solution of lime, dried, re-burned, and ground. It is very much harder and stronger than plaster of Paris. *Parian Cement:* Plaster of Paris mixed with a 10 per cent. solution of borax. *Stucco:* Plaster of Paris treated with a solution of gelatine or glue.

Cement Stone Group (*Geol.*) A subdivision of the Scottish Lower Carboniferous Rocks which corresponds to the Ballagan Beds of the west of Scotland and the Lower Limestone Shale. The name was given on account of the occurrence, in the shales of these rocks, of thin bands of argillaceous limestone like those found in the Lias. They are mostly quite useless for the manufacture of cement. These rocks were erroneously supposed to be of older date than any carboniferous rocks known in England.

Cement Tester (*Build., etc.*) A small TESTING MACHINE used for finding the tensile strength of samples of cement, which are moulded into a special form for the purpose. *See* TESTING MACHINES.

Cendal. *See* SENDAL.

Censer (*Archæol., etc.*) A vase or vessel for burning incense. The heathen censer generally stood, and was in form of a tripod. The Christian Church uses a swinging censer, hung by chains. In the Roman Catholic Church they are called THURIBLES.

Centaur (*Myth.*) A fabulous creature having the body of a horse and a man's torso, head, and arms issuing from the neck of the animal. Often introduced in Greek and Roman sculpture.

CENTAUR (*Myth.*)

Centering *or* **Centring** (*Build.*) The timber frame supporting an arch during the process of construction.

—— (*Eng.*) Marking the centres on work for the drilling machine, or the ends of the axis of a piece of work to go into the lathe, by means of a centre punch.

Centigrade Scale (*Heat*). The scale of temperature universally used in science; the difference in temperature between the freezing and boiling points of pure water is divided into 100 equal parts, the former being marked 0° and the latter 100°. The scale thus obtained is extended by means of equal divisions or degrees above and below the fixed points.

Centimetre. *See* WEIGHTS AND MEASURES.

Central Load (*Eng., Build., etc.*) A weight which is concentrated at the centre of a beam or other structure.

Centre Chuck (*Eng.*) A chuck (*q.v.*) which automatically adjusts work of a cylindrical or circular form, so that its axis coincides with the line of centres of the lathe. The jaws are moved by a screw, lever, or other device, and are so connected together that however they are moved they are always equidistant from the central axis of the chuck.

Centre Flower (*Plast.*) A plaster ornament in the centre of a ceiling.

Centre Nailed (*Build.*) Slates having the nail holes near the centre of their length.

Centre of a Lens (*Light*). In the case of a very thin lens, the centre is the point at which the axis cuts the lens: a ray passing through this point will not be bent by the lens, whatever its direction. In the case of a lens of finite thickness it is a point (which is not necessarily within the lens) such that any ray passing through it is undeviated. Let AC be a

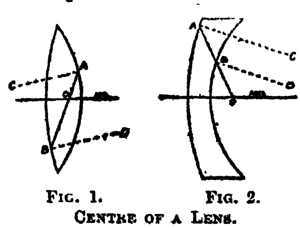


FIG. 1. FIG. 2.
CENTRE OF A LENS.

NORMAL (*q.v.*) to one surface of the lens at A, and BD be the normal to the second surface which is parallel to AC. Join AB, then the point O is the centre.

Centre of Curvature. If two normals be drawn to any curve, they will intersect on the concave side of the curve. If the two points from which they are drawn approach one another till they are at an infinitesimal distance apart, then the point of intersection of the two normals is called the CENTRE OF CURVATURE of the curve, and the distance from the curve to this centre is termed the RADIUS OF CURVATURE.

Centre of Gravity (*Phys., Mechanics*). A point in a body through which passes the resultant of all the parallel forces exerted by gravity on the particles composing the body. In more practical language the centre of gravity may be said to be a point about which the body would balance in whatever position it might be placed.

Centre of Oscillation (*Physics*). *See* PENDULUM.

Centre of Pressure (*Phys.*) When a fluid pressure is applied to any surface, a point can be found through which the resultant pressure (or resultant of all the forces exerted on every element of area of the surface) acts. This point is the Centre of Pressure.

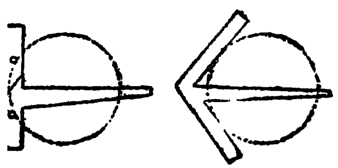
Centre of Suspension (*Physics*). *See* PENDULUM.

Centre Piece (*Plast.*) *See* CENTRE FLOWER.

Centre Plates (*Pattern Making*). Metal plates used for holding together parts of a jointed pattern while being turned in the lathe.

Centre Punch (*Eng.*) A punch used for marking the point where the centre of a hole is to be drilled, or as a guide for some other measurement.

Centre Square (*Eng.*) A form of square with two studs on the stock. When these studs touch the circumference of a circle, one edge of the blade of the square passes through the centre of the circle, so that by marking a line with two positions of the square the centre of the circle can be found. In another form there are two straight edges fixed at an angle with each other, forming a wide V, between the arms of which the circular object can be placed. The blade of the square is fixed so that one edge bisects the angle of the V, and therefore passes through the centre of the square. Both forms of centre square are shown in the illustration.



CENTRE SQUARES.

Centre Weighted Governor (*Eng.*) An engine governor which has a heavy weight attached to the central spindle, so that it is moved up and down when the speed varies. *See* GOVERNOR.

Centrifugal *and* Centripetal Force. When a body is constrained to move along a curve, it exerts a force along the outward-drawn normal to the curve. This force is termed the Centrifugal Force. Its amount is $m\frac{v^2}{r}$ where m is the mass of the body, v its velocity, and r the radius of curvature of the path. The force which causes the body to continue in its curved path is equal in amount, but opposite in direction, to the centrifugal force: it is often termed the CENTRIPETAL FORCE. If a mass, attached to a string, be whirled round in a circle, the centripetal force is the pull exerted by the string.

Centrifugal Pump. A pump in which a high velocity is given to the water by the blades of a rapidly rotating fan. Its continuous action and the absence of valves are its chief advantages.

Ceramics. *See* POTTERY AND PORCELAIN.

Ceramography. Historical and technical description of pottery.

Cerebellum (*Zoology*). The term applied to a part of the hind brain. It functions in maintaining the balance of the body.

Cerebrum. The mass of nervous matter forming the anterior portion of the brain. In the higher vertebrates it constitutes the largest part of the brain, and in man fills nearly the whole cavity of the skull.

Ceresine. An earth wax obtained from OZOKERITE (*q.v.*) Used principally for mixing with beeswax.

Cerium (*Chem.*). Ce. Atomic weight, 140. A rare metal resembling iron in appearance; it occurs as silicate in the rare mineral CERITE; it belongs to the same group of elements as carbon in the Periodic System (*q.v.*) The dioxide CeO_2 forms 1 per cent. of the WELSBACH INCANDESCENT MANTLE (*q.v.*) The crude sulphate made from cerite is used in dyeing; the oxalate is used in medicine to prevent vomiting.

Cerography. (1) Writing, painting, or engraving on wax. (2) The encaustic painting of the ancients. (3) Painting in wax colours.

Ceroplastic. The art of modelling in wax. This art was practised in early times and in the Renaissance, the figures often being coloured. Some of the finest examples are Michael Angelo's studies, now at South Kensington.

Cerulean (*Paint.*) Of the colour of the blue sky: azure.

Cerulein. *See* DYES AND DYEING.

Cerussite (*Min.*) Carbonate of lead, $PbCO_3$. Oxide of lead = 83·5, carbonic acid = 16·5 per cent. Usually in rhombic crystals, but also massive. The lustre is peculiarly brilliant. Twinning often produces a radial arrangement of the individual crystals. It is probably derived from the decomposition of Anglesite in many cases. In quantity it is a valuable ore of lead. Found at Caldbeck Fells, Alston Moor in Cumberland, Cornwall, Dumfriesshire, and many places abroad.

Ceryl Alcohol. $C_{27}H_{55}OH$. A white crystalline mass; melts at 79°. Combined with CEROTIC ACID, $C_{27}H_{54}O_2$, it forms CHINESE WAX, $C_{26}.H_{53}COOC_{27}H_{55}$. It belongs to the same series of alcohols as common or ethyl alcohol.

Cesspools (*Hygiene*). Cavities to receive the sewage from houses in districts where the water-carriage system for the removal of waste matters has not been adopted. They should fulfil the following conditions: Be absolutely watertight, well ventilated, placed a safe distance from wells and streams, regularly emptied and cleansed, and without overflows.

—— (*Plumbing*). A box lined with lead, at the end of a gutter.

Cestus (*Archæol.*) A boxer's glove, used by the Greeks and Romans. It was generally formed of thongs of leather wound round the hand and wrist. Metal bosses were sometimes added, or the leather was loaded with lead or iron.

Cetyl Alcohol. $C_{16}H_{33}OH$. A white crystalline mass; melts at 49·5°. Combined with palmitic acid, forming cetyl palmitate, $C_{15}H_{31}COOC_{16}H_{33}$, it is the chief ingredient of SPERMACETI. It belongs to the same series of alcohols as common or ethyl alcohol.

C.F. (*Music*). Abbreviation for *canto fermo*.

Chabazite (*Min.*) A rhombohedral ZEOLITE (*q.v.*) occurring in drusy cavities (*q.v.*) in basic lavas. Composition, a hydrous silicate of aluminium, calcium, and potassium. Found at Giants' Causeway, Ireland, Greenland, United States, etc.

Chain. A number of loops of metal linked together. Each loop is welded up, in the case of large chains; in smaller ones it may be brazed, soldered, or merely bent into form, according to its material and the purpose for which it is required.

—— (*Surveying, etc.*) In surveying, the surveyor's chain is the instrument most frequently employed for the direct measurement of distances. It is in the form of a chain of one hundred links of iron or steel wire. Its length is usually 66 ft. *See also* WEIGHTS AND MEASURES.

Chain Adjustment (*Cycle*). The device by which the hub of the back wheel and the sprocket wheel on it can be moved farther from the crank axle to "take up" the slackness due to stretching of the chain. The back axle is moved in the fork ends by means of the "adjusters," and held in place by the nuts which screw the collars on the axle closely up to the slotted fork ends.

Chain Barrel (*Eng.*) A cylinder on which a chain is wound up in some forms of machinery, such as cranes. It may have a groove in which the chain can lie, or may be a plain cylinder.

Chain, Driving (*Cycles and Cars*). There are two chief types: BLOCK CHAINS, in which the two side links are connected to a solid piece or "block," and ROLLER CHAINS, in which the screwed pin on which the links hinge runs through a tubular roller, which can revolve as it passes over the teeth of the chain wheels, thereby diminishing the friction. Many special forms of driving chains are now made for the cycle, motor, and engineering trades. *See also* CYCLES.

Chain Moulding (*Architect.*) An enriched moulding resembling a chain, used in Norman work.

Chain Pillars (*Mining*). Masses of rock left on each side of a gangway or principal level to prevent the collapse of the roof.

Chain Pump (*Eng.*) A pump in which a number of discs, fixed on a chain, run through a cylindrical barrel, and serve as a succession of pistons for raising water up through the barrel.

Chain Riveting (*Eng.*) An arrangement of rivets in parallel rows.

Chain Survey. A survey carried out by means of the chain only, no theodolite, etc., being used. *See also* TRIANGULATION.

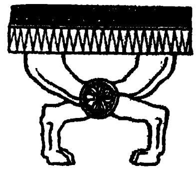
Chain Warp (*Cotton Weaving*). A WARP (*q.v.*) of considerable length and fewer threads than a balled warp. It is looped or linked in the form of a chain so as to facilitate its progress during dyeing and sizing operations. Usually prepared on a chain or lease warper.

Chain Wheel (*Cycles and Motor Cars, etc.*) A wheel with teeth of a suitable form to engage the links of a driving chain without shock or undue friction. The block or roller (*see* CHAIN, DRIVING) must be able to lie between two teeth with the necessary clearance.

Chair (*Eng.*) The iron casting by which a rail is fixed to the sleepers on a railway. The rail drops into a wide opening in the chair, and is fixed by large wedges of wood.

—— (*Glass Manufac.*) A group of workmen in a glass manufactory who attend to a certain number of crucibles. *Cf.* COMPANIONSHIP (*Typog.*)

——**, Curule.** A folding seat used by Roman officials as a mark of distinction. It was generally richly decorated with ivory inlay, gold, etc. Those entitled to use such a seat were called *Curule magistrates*.



CHAIR, CURULE.

Chair Rail (*Carp.*) A wood moulding fixed to the wall to protect the plaster from injury by the backs of chairs.

Chair, Sedan. So called from *Sedan* in the north of France, where first used. A closed vehicle for carrying one person. It was glazed at the sides and in front, often elaborately decorated, and was borne by two men by means of shoulder straps attached to two long poles. The Sedan chair was extensively used in this country by the wealthier classes during the seventeenth and eighteenth centuries.

Chalcanthite (*Min.*) Hydrous sulphate of copper, $CuSO_4 . 5H_2O$. Oxide of copper = 31·8, sulphuric anhydride = 32·1, water = 36·1 per cent. Also called BLUE VITRIOL. It occurs in sky blue crystals of the anorthic system and in encrusting masses. It results in nature from the decomposition of copper pyrites. Found in Cornwall, Ireland, the Harz, etc.

Chalcedony (*Geol.*) A mixture of COLLOIDAL (*q.v.*) or opaline silica with a microcrystalline form whose exact nature is as yet imperfectly known. Provisionally this crystalline constituent is referred to as QUARTZINE. Chalcedony forms the chief constituent of agates, and it is also the basis of flint, chert, jasper, carnelian, bloodstone, sard, etc. In many cases it has originated through the deposition of silica derived from the decomposition of silicates. It often occurs as a content of the steam cavities of lavas, sometimes in stalactitic forms. When deposited in horizontal layers it is called ONYX. The onyx of jewellery is produced by allowing the more porous layers of such chalcedony to take up a solution of sugar, which is then blackened by exposure to sulphuric acid.

Chalcocite (*Min.*) A synonym for COPPER GLANCE (*q.v.*)

Chalcography. The art of engraving on copper or brass. *See* ENGRAVING.

Chalcolite (*Min.*) A synonym for COPPER URANITE (*q.v.*)

Chalcopyrites (*Min.*) A synonym for COPPER PYRITES (*q.v.*)

Chalcotrichite (*Min.*) A variety of CUPRITE, the red oxide of copper (*q.v.*)

Chalcotript. One who takes rubbings of "brasses."

Chalice. A name generally given to the cup in which the wine for consecration is placed at the celebration of Holy Communion. Chalices are generally made of either gold or silver, and are often of beautiful design and elaborate workmanship.

Chalk (*Geol.*) A term applied exclusively to the marine limestones of the Upper Cretaceous Rocks of

Britain. Typical chalk is soft and earthy in texture; but this type is confined to the south-east of England. It is a rock of deep water origin, formed from a deposit analogous to the recent foraminiferal oozes. It ranges in thickness from a hundred feet or so to more than ten times that amount. *See also* CALCIUM COMPOUNDS.

—— (*Paint.*) Chalk is often prepared and used for drawing. The name is then generally used in the plural. Applied also to other coloured preparations resembling chalk used in the form of crayons for drawing.

Chalk Drawing. A drawing sketched and filled in with black or coloured crayons.

Chalking (*Dec.*) A condition of white or light paint work in which white lead has been used, and where the paint has a chalky appearance and may be rubbed off with the hand like whitewash. Chalking is common near the sea. It may be prevented by adding zinc white (*q.v.*) to the white lead.

Chalk Line. A long piece of string (on a reel) chalked and drawn tight, for marking straight lines on long pieces of work.

Chalybeate Waters. Waters containing iron in the form of ferrous carbonate held in solution by carbon dioxide. Famous waters of this kind are those at Homburg, Spa, Tunbridge Wells, Harrogate.

Chalybite (*Min.*) Carbonate of iron, also called SIDERITE. It occurs massive or in rhombohedral crystals with curved faces. Usually weathers to a brownish or black colour. It is an important ore of iron, containing 60 per cent. of iron and 36 per cent. carbon dioxide, and often a little calcium, etc. It is often found as a replacement product of limestone, calcium being replaced by iron. Found in Cornwall, Alston Moor, and Cleator Moor in Cumberland, in Saxony, the United States, etc.

Chambered Core (*Foundry*). A CORE (*q.v.*) which is larger at its central portion than its ends.

Chamfer (*Carp., etc.*) A narrow flat surface formed along the edge of a piece of material by removing the sharp edge or ARRIS (*q.v.*)

Chamfer Plane. A plane with guides or fences that can be set so as to form a chamfer of any required width.

Chamfron (*Arm.*) The armour for protecting the forepart of the head of a warhorse.

Chamois (*Zool.*) *Rupricapra tragus* (family, *Bovidæ*). A well known goatlike antelope of Southern Europe. The skin originally furnished CHAMOIS LEATHER (*q.v.*)

Chamois Leather *or* **Wash Leather.** Originally obtained from the chamois; now made from the flesh-split of a sheepskin. It is first limed, split, then put into machines, sprinkled with cod-liver oil, and pummelled, more oil being added at intervals. The skins are then allowed to heat until they turn yellow. They are then washed free from excess of oil. It is largely used in various trades and for domestic purposes for cleaning.

Champlevé (*Enamel*). *See* CLOISONNÉ.

Chancel (*Architect.*) *See* CHOIR.

Chance's Process (*Chem.*) A method of recovering the sulphur from ALKALI WASTE. *See* ALKALI. There are two stages in the reactions of the process. Carbon dioxide is passed through a series of vessels containing the alkali waste suspended in water. In the earlier vessels the carbon dioxide forms carbonate of lime (which can be roasted to yield fresh supplies of carbon dioxide) and sulphuretted hydrogen, thus: $CaS + H_2O + CO_2 = CaCO_3 + SH_2$. This mixture of CO_2 and SH_2 passes into the succeeding vessels, where the SH_2 first forms hydrosulphide of lime, which in turn is decomposed by the carbon dioxide, yielding more sulphuretted hydrogen, thus: (*a*) $CaS + SH_2 = Ca(SH)_2$; (*b*) $Ca(SH)_2 + H_2O + CO_2 = CaCO_3 + 2SH_2$. The sulphuretted hydrogen is collected in gasholders, and utilised either by being completely burned to sulphur dioxide and water, the sulphur dioxide being used for the manufacture of sulphuric acid (*q.v.*), or it is burned in a CLAUS kiln with a supply of air only sufficient to form sulphur (technically known as RECOVERED SULPHUR) and steam, $SH_2 + O = S + H_2O$.

Change Wheels (*Eng.*) The gear wheels employed in a screw-cutting lathe to connect the MANDREL (*q.v.*) and the LEADING SCREW (*q.v.*), in order to produce the required traverse or motion of the slide rest in screw-cutting.

Changing Notes (*Music*). Dissonant notes used in counterpoint, third species, on the second and third beats of a bar, a third apart; one above and the other below the harmony note.

Channel Iron (*Eng.*) Wrought iron bars rolled into a channel-shaped section—*i.e.* forming three sides of a rectangle. Used for girders, roofs, and other structural purposes.

Chantry. A chapel, altar, or other portion of a church endowed for the maintenance of a certain number of priests to sing daily mass, generally for the souls of the founders.

Chape. (1) The metal mounting of a scabbard, particularly that at the tip. (2) The part of a buckle by which it is fastened to the strap.

Chapel (*Typog.*) A meeting or union of the men employed in a printing works, for the purpose of arranging or considering matters affecting themselves or the trade generally. The term is thought to be derived from Caxton's connection with Westminster Abbey. The chairman or spokesman is termed the "Father" of the Chapel.

Chapelle de Fer (*Arm.*) A plain iron helmet with a brim, shaped like a hat. It preceded the BASCINET (*q.v.*)

Chaperon. A small ornamental shield formerly placed on the horses' heads at funerals.

Chaplet *or* **Stud** (*Moulding*). A metal support for a core in the mould.

Characteristic Curves (*Elect. Eng.*) Curves used to show the relation between the CURRENT and the VOLTAGE in dynamos and motors, or the relation of TORQUE (*q.v.*) and SPEED in motors. Much information as to the working of the machine can be obtained from an examination of these curves. *See also* INTERNAL *and* EXTERNAL CHARACTERISTICS.

Charcoal. The residue from the destructive distillation of wood. Wood heated to a high temperature out of contact with the air, in order that the volatile portions may be driven off, yields very nearly pure carbon. Animal matter also yields a very pure carbon. *See* ANIMAL CHARCOAL.

—— (*Paint.*) Sticks of willow charcoal are used as crayons, especially for outline drawing on canvas.

Charcoal Blacking (*Moulding*). Finely ground charcoal for dusting over the surfaces of a mould.

Charcoal Burner (*Dec.*) A portable grate in which charcoal is burned; used in burning off old paint previous to repainting. Is becoming rapidly superseded by the burning-off lamp, but is useful when the old painted surface is flat and of considerable extent.

Charcoal Iron (*Met., etc.*) Iron prepared in a furnace where charcoal is the only fuel. It is the finest and purest variety of iron, and of great value for electrical work, such as transformer cores, armature discs, etc. Now only made in Sweden.

Charcoal Plate (*Eng.*) Thin sheets of iron for the production of tin plate, made from iron refined with charcoal instead of with coke.

Charge (*Her.*) Any heraldic figure depicted on a coat of arms.

—— (*Met.*) The mixture of ore and fuel introduced into a furnace at one time.

—— (*Eng.*) The mixture of air and gas drawn into the cylinder of a gas engine at one stroke.

Charged (*Her.*) A shield is charged when it bears upon its surface some heraldic figure.

Charge, Electrical. A quantity of electricity at rest as distinguished from a current. It is obviously necessary to define "Electricity" with exactness before a "Charge" can be properly defined, and this has scarcely been done up to the present. *See also* ELECTRICITY.

——, **Residual** (*Elect.*) A small charge which may usually be obtained from a LEYDEN JAR or other CONDENSER (*q.v.*) after it has been discharged once. Frequently several residual charges may be obtained in succession, gradually diminishing in amount until too small to be detected.

Chariot (*Archæol.*) The earliest and most primitive form of carriage, consisting generally of a low platform on two wheels and a raised and curving protection in front.

Charles' Law (*Heat*). The volume of all gases varies as their absolute temperature (*q.v.*) if the pressure remain unaltered. Expressed algebraically we get, if V_t and V_o are the volumes at $t°$ and $0°$, respectively (on the Centigrade scale)

$$\frac{V_t}{V_o} = \frac{273 + t}{273}$$

The same law may be expressed by the statement that all gases have (approximately) the same coefficient of expansion, which is about ·00367 of the volume at 0°C.

Charlton White (*Dec.*) A valuable white pigment. *See* ORR'S ZINC WHITE.

Charm (*Archæol.*) *See* AMULET.

Chase (*Build.*) A channel cut in a wall to receive pipes, etc.

—— (*Typog.*) An iron frame for holding type when set up for printing.

Chased. The term is applied to metal or plate embossed and engraved in relief.

Chase Mortise (*Carp. and Join.*) A mortise with a sloping surface to slide a tenon into.

Chaser (*Eng.*) A tool used for cutting screws by hand in the lathe; rarely used except in light work, such as that of opticians, who have to cut fine screws on thin brass tubing. It consists of a flat blade having a number of teeth at the end, which correspond in shape to the grooves between the threads of the screw which it is required to cut. The chaser is moved along the top of the T-REST (*q.v.*) as the work rotates in the lathe. To adjust the rate at which the tool must be moved at first in order to "strike" the thread requires considerable skill; but when the thread has once been started, the finishing process is not very difficult. On this account the chaser is often used for finishing off a thread which has been struck or started by means of STOCKS AND DIES (*q.v.*) or by other mechanical means.

Chase Wedge (*Plumbing, etc.*) A hard wood wedge with a handle. Used for bossing sheet lead.

Chasing (*Eng.*) The process of cutting screws with the CHASER (*q.v.*)

Chasuble (*Cost.*) The chief ecclesiastical vestment, worn by all grades of the clergy. Its original form was a circle, with a hole in the middle for the head to go through; but later the sides were cut away to give freedom to the arms. It is worn over all other vestments.

Chatter (*Eng.*) The waviness produced on the surface of work by vibration of the tool, etc.

Check (*Eng.*) (1) A general name for a joint in which one part fits into another. (2) A disc on which is marked a number assigned to each workman for convenience in timekeeping. The check is left at the timekeeper's office by each man on entering the works.

Checking Motion (*Cotton Weaving*). A mechanism for automatically changing shuttle boxes on a loom, so that shuttles containing different colours of weft may be brought into action to give any desired colouring or check effect. Two distinct systems are in use: (1) Rising and falling boxes. (2) Revolving boxes.

Check Nut *or* **Lock Nut** (*Eng.*) A subsidiary nut screwed on a bolt on top of the ordinary nut to lessen the chance of its working loose.

Check Pattern (*Textiles*). Applied to all patterns consisting of squares, whether of colour or weave.

Check Rail (*Eng.*) A third or subsidiary rail laid on the inner side of a sharp curve on a railway; it just touches the side of the flange of the wheel, and relieves the pressure on the outer rail.

Check Valve (*Eng.*) A valve which prevents the escape of water through the feed pipe of a boiler.

Checky (*Her.*) A shield divided into small squares, generally six rows, sometimes less, the squares being alternately of different tinctures, like a chessboard.

Cheek (*Carp., etc.*) (1) The piece forming the side or jaw of a carpenter's bench screw or vice. (2) A general term for the sides or flanks of various objects, *e.g.* the sides of a tenon.

Cheese (*Foods*). Prepared by curdling, by means of some kind of acid, whole milk, skimmed milk, or milk to which cream has been added. RENNET (*q.v.*), which is obtained from the fourth stomach of the calf, is generally used for the purpose. Cheese is highly nutritious, containing a large amount of proteids and fat. A substance called Annatto is much used for colouring cheese. Cheshire, Cheddar, and double Gloucester cheeses are made from whole milk, and Stilton from a mixture of milk and cream.

Chelsea. The Porcelain Manufactory at Chelsea was established about the year 1745. In 1769 the business and the works were sold to William Duesbury, of Derby, and the manufactory was closed in 1784. During its forty years of existence the Chelsea factory

produced some of the most beautiful of English SOFT PASTE. The porcelain was celebrated for its beautiful glaze, its brilliant colours, fine painting, and rich gilding. The DARK BLUE of Chelsea is especially famous. For marks, *see under* POTTERY AND PORCELAIN.

Chemical Action. When one substance or when a number of substances react under such conditions that one or more new substances are produced, chemical action is said to have taken place. The occurrence of chemical action is dependent on many conditions; *e.g.* (1) *Temperature: e.g.* arsenic pentachloride can be made by passing chlorine into the trichloride below $-25°$; above this the pentachloride cannot exist: (2) *Pressure: e.g.* in Brin's oxygen process (*q.v.*) barium dioxide is formed at 700° under a pressure of two atmospheres, but at the same temperature it is decomposed under a pressure of a few inches of mercury. (3) *Mass: e.g.* when steam is passed over red hot iron the magnetic oxide of iron (Fe_3O_4) is produced and hydrogen liberated; but if hydrogen is passed over heated magnetic oxide, iron and steam are produced. Hence it is clear that for a given mixture of iron and magnetic oxide the direction the reaction will take will depend on the relative masses of steam and hydrogen passing over the mixture. (4) *Light:* equal volumes of hydrogen and chlorine may be kept mixed together in the dark indefinitely, but light brings about union between them. (5) *Catalytic Action. See* CATALYSIS.

Chemical Affinity. *See* AFFINITY, CHEMICAL.

Chemical Engineering. *See* PHYSIO-CHEMICAL ENGINEERING.

Chemical Equations. A chemical equation is a collection of CHEMICAL FORMULÆ (*q.v.*) so arranged as to indicate what substances take part in a reaction and the relative amount of each, and what substances result from the reaction and the relative amount of each; also an equation is always an expression of the principle of the INDESTRUCTIBILITY OF MATTER; *e.g.* $Zn + H_2SO_4 = ZnSO_4 + H_2$ indicates that 65 parts by weight of zinc acted on by 98 parts of sulphuric acid will give 161 parts of zinc sulphate and 2 parts of hydrogen, *i.e.* $(65+98)=(161+2)$: but the equation does not indicate whether heat must be applied; whether heat is evolved or absorbed; that the acid must be dilute; and the zinc in contact with a less easily oxidised element (carbon, iron, copper, or platinum) than itself. Sometimes instead of the sign of equality $=$, the sign $\rightleftarrows$ is used; the latter sign means that the reaction will take place in either sense according to the conditions, *i.e.* the substances denoted by either of the two sides of the equation may combine to produce those on the other. *See* CHEMICAL ACTION.

Chemical Formulæ. A formula is a group of CHEMICAL SYMBOLS (*q.v.*) intended to denote a particular compound; the formula also always stands for one molecule of the compound and therefore a certain relative weight of it, and from the symbols composing the formula we learn what elements are contained in the compound, while from the numbers suffixed to the symbols we learn the number of atoms of each element in a molecule of the compound. A formula which tells us no more than this is an EMPIRICAL FORMULA (*q.v.*) A formula so written as to indicate some of the reactions of formation or decomposition of a compound is called a CONSTITUTIONAL FORMULA. A formula so written as to show the supposed mode of union of all the atoms in the molecule of the compound with each other is called a GRAPHIC FORMULA: *e.g.* H_2SO_4 is the empirical formula for sulphuric acid; $SO_2(OH)_2$ is a constitutional formula, and suggests, among other things, that it is a ***dibasic*** acid. $\begin{matrix}O\\O\end{matrix}\!\!\gg\!S\!<\!\begin{matrix}O-H\\O-H\end{matrix}$ is the graphic formula, and, ignoring spacial considerations, represents the probable mode of union of the atoms in the molecule. *See also* STEREOISOMERISM.

Chemically Formed Rocks. As the term is usually employed these comprise but a small variety of rocks, of which the chief are ROCK SALT, GYPSUM, and DOLOMITE (*q.v.*) Strictly speaking, these should be regarded as MINERALS rather than ROCKS (*q.v.*)

Chemical Pulp (*Paper Manufac.*) Pulp made from wood or other crude cellulose by treatment with caustic soda or bisulphite of lime.

Chemical Symbols. A chemical symbol is a letter, or two letters, used to denote a particular element, and it also denotes one atom, and consequently a particular relative weight of the element. When the symbol, not being joined to other symbols, has a number suffixed to it, the number indicates the number of atoms supposed to be united to form the molecule of the element. Thus H stands for 1 Atom of Hydrogen; H_2 for 1 Molecule of Hydrogen. Hg stands for 1 Atom of Mercury (*Lat.* HYDRARGYRUM) and also for the Molecule of Mercury.

Chenille (*Fabric*). A figured pile fabric, such as tablecovers, curtains, carpets, composed of chenille weft yarn.

—— (*Thread*). This is a woven fringed thread, consisting of a few cotton or foundation threads to which the weft is added in a prescribed order of colouring.

Cheniscus (*Archæol.*) The termination of the stern or prow of Greek and Roman ships which turned up like a goose's neck and frequently had a goose's head carved at the extremity.

Chequers (*Eng., etc.*) (1) Projections of rectangular or diamond shape on plates of metal forming a floor. (2) An openwork arrangement of brickwork through which the hot gases pass in REGENERATIVE FURNACES (*q.v.*)

Cherry. The stone fruit of ***Prunus cerasus*** (order, *Rosaceæ*). *See also* WOODS.

Cherry Coal. *See* COAL.

Cherry Red. A bright red heat (*q.v.*)

Chert (*Geol.*) Usually occurs in the form of concretionary nodules in limestone in the same manner as flint occurs in chalk. Both flint and chert consist fundamentally of a mixture of opaline and cryptocrystalline silica, which is known as CHALCEDONY (*q.v.*); but various impurities are present in both. Those in chert are usually more or less calcareous. Like flint, chert has been formed from weak solutions of silica derived in the first instance from organic structure, such as the siliceous spiculæ of sponges.

Cherub (*Art.*) The head of a beautiful child angel, winged at the neck.

Chessylite (*Min.*) A synonym for AZURITE (*q.v.*), derived from Chessy in France, an important locality for the mineral.

Chest (*Furn.*) A large box or coffer. A very common article of furniture in the middle ages; often made of oak and carved.

Chestnut. *Castanea vulgaris* (order, *Fagaceæ*). The sweet chestnut is of value not only for its edible fruits, but also for the bark, used as a tanning agent. The prepared saplings form the walking sticks known in the trade as "Congo sticks." *See also* WOODS.

Cheval de Frise (*Architect.*) A wood or iron bar from which spikes project. It is frequently used as a means of protection on ground floor window sills and on parapet walls.

Cheviot (*Woollen Manufac.*) A fancy woollen fabric made largely of cheviot and cross-bred wools.

Chevron (*Architect.*) A repeating ornament used on Norman mouldings. It is also known as the ZIGZAG, a name which indicates the form of the ornament.

—— (*Her.*) One of the honourable ordinaries. Formed by two bands one-fifth or one-third the width of the shield, issuing from opposite sides of the base of the shield, and joined rather above the centre.

Chevronel (*Her.*) Diminutive of the chevron.

Chevronny (*Her.*) Lines or bands in form of chevrons dividing a shield. *See* CHEVRON.

Chiaroscuro (*Paint., etc.*) The distribution of light and shade in a picture. (1) The art of establishing a right relation between the parts of a picture which are in light and those which are in shadow, so that a proper degree of form-definition and tone-gradation may be obtained. (2) As a factor in composition, the division of the area of a picture into light and dark surfaces so as to produce an agreeable optical effect and an attractive pictorial pattern. The study of chiaroscuro was based upon the attention given by the great artists of the Renaissance to modelling—*i.e.* to the use of shading, by which a correct impression of variations of projection and recession could be created. The chief masters of chiaroscuro were Rembrandt, Titian, Rubens, and Coreggio. The term was, at one time, applied to pictures in which only two colours were employed, black and white.

Chiastolite (*Min.*) *See* ANDALUSITE.

Chicory (*Foods*). The powdered root of a wild endive (*Cichorium intybus*). Chicory differs from coffee in containing a much larger quantity of sugar, a smaller amount of fat, and no caffeine. Substances used to adulterate coffee may be employed to adulterate chicory. It is generally added to coffee, the mixture being readily detected by examination with the microscope.

Chief (*Her.*) The most honourable ordinary. Placed at the head or top of a shield, and occupying one-third of the field. Formed by one horizontal straight line.

Chiesa (*Music*). *See* CAMERA.

Chili Copper (*Min.*) Ore containing black oxide of copper.

Chili Saltpetre *or* **Caliche** (*Chem.*) Sodium nitrate, found native in Chili and largely exported as a nitrogenous manure and for use in various chemical manufacturing processes.

Chill (*Eng.*) A metallic mould used for CHILLING (*q.v.*)

Chilled (*Paint.*) The varnish on a picture will become clouded and dim when hung in a damp atmosphere; it is then said to be chilled.

Chillies. *See* CAPSICUM.

Chilling (*Eng.*) The hardening of a casting by the use of a mould made of metal. Only certain kinds of cast iron can be successfully chilled; when properly done, a very hard surface is produced.

Chimæra, Chimera (*Myth.*) A fabulous fire-breathing monster composed of various parts of different animals—*viz.* a lion's head with wings, the body of a goat, and the tail of a dragon; or other fantastic combinations.

CHIMÆRA, LYCIAN TERRACOTTA, BRITISH MUSEUM.

Chimney (*Hygiene*). The chimney plays an important part in the ventilation of rooms, being a powerful extractor. When a fire is burning in the grate, a constant current of air passes up the chimney at a rate varying from 3 to 6 ft. per second. Chimneys are often tapped near the ceiling for the insertion of outlet ventilators, such as Boyle's and Arnott's valves. *See* ASPIRATION, VENTILATION BY, *and* VENTILATORS.

Chimney Bar (*Build.*) A bar of iron supporting the brick ring (arch) of a fireplace opening.

Chimney Bond (*Build.*) The BOND or mode of laying the bricks used in the WITHES (*q.v.*) of chimneys; all the bricks are laid as STRETCHERS (*q.v.*)

Chimney Breast (*Build.*) The part of the walls containing the flues, and projecting into the room.

Chimney Shaft (*Build.*) (1) A tall chimney containing one flue. (2) A factory chimney.

Chimney Stack (*Build.*) A chimney containing a number of flues grouped together. In engineering, the term is often applied to a single lofty shaft, though chimney shaft is more correct in this case.

China (*Pot.*) (1) A species of earthenware, semi-transparent, first manufactured by the Chinese. (2) Any imitation of that ware. *See* BÖTTCHER WARE, POTTERY AND PORCELAIN.

China Clay *or* **Kaolin.** A pure form of clay resulting from the prolonged action of subterranean water upon felspars, chiefly those which contain potash. China clay is not simply the result of the weathering of felspar, as is often thought to be the case. It is of considerable importance in the arts not only for the manufacture of china and porcelain, but also as an excellent pigment, requiring only levigation and drying to fit it for use. It is largely employed in the manufacture of paper, as a filler, and as a base in the manufacture of LAKES (*q.v.*) *See also* ALUMINA.

Chinchilla. *Chinchilla lanigera* (family, *Chinchillidæ*). A small squirrel-like rodent belonging to South America. The soft fur is greatly valued.

Chiné (*Silk*). A silk fabric having a printed figure of somewhat hazy, undefined appearance. The silk is first warped and passed through the loom, receiving a few loose picks at intervals of about 12 in.; it is then removed from the loom and printed, after which the HOLDING WEFT (*q.v.*) is removed, and it is again placed in the loom and woven up with TABBY TIE (*q.v.*)

Chinese Paper. Sometimes called India paper, manufactured from the bamboo fibre. It is very fine and of a pale yellow colour.

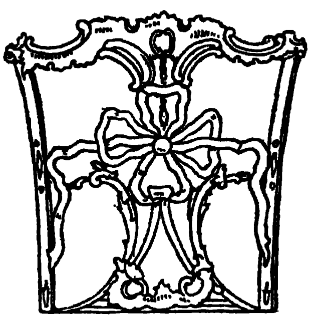
Chinese Red (*Dec.*) Another name for Derby red (*q.v.*)

Chinese Wax. *See* CERYL ALCOHOL.

Chinese White (*Paint.*) A pigment used by artists, consisting wholly of ZINC WHITE (*q.v.*) It is employed both in oil and watercolour painting.

Chippendale Book Plates. This name has been given popularly to the book plates issued between the middle and end of the eighteenth century. They possess the following characteristics, as given in Warren's *Guide*: "A frilling or border of open shellwork is set close to the rounded outer margin of the escutcheon. It is, in fact, a border imitating the pectinated curves and grooves on the margin of the scallop shell." It was studiously asymmetrical, and in latter days it was enriched (some say debased) by the addition of flowers and fruits, or animals, real or mythological. "Chippendale" must not be confounded with "Rocaille" or "Rococo," these being French in character; whereas the first named may be considered national.

Chippendale Furniture. A generic term including originally only chairs, stools, tables, bedsteads, firescreens, and mantelpieces, made by Thomas Chippendale, whose father, of Worcestershire descent, came up to London and settled as a cabinet-maker at No. 60, St. Martin's Lane, excelling as a carver of mirror frames. Thomas Chippendale, "The King of Designers," published in 1754 *The Gentleman and Cabinet Maker's Director*, containing some two hundred designs. While the rococo style of Louis XV. is reflected in his *bombé* fronted commodes, and a few of his chairbacks; while, again, some of the latter are based on Sir William Chambers' Chinese style, Chippendale, nevertheless, founded a style of his own. He gave to his bookcases and clothes presses "different" or "odd" doors, to his tables and moulded chair legs "different" feet. He divided glass, where used, unequally. It is essentially as a designer of chairs that he appeals to us. Actual Chippendale work is in mahogany *without inlay*. The wood was carefully selected and well seasoned. Frets were made by gluing together several thin pieces with the grain running in different directions, thus forming a strip giving immense strength, an object further secured by joining the "splat" of the chair into the framework—a plan since neglected. The choice features of the chairs consist of the carved scroll and interlaced "ribband" backs, and the elaborately sculptured cabriole legs. Equally famous are the "claw and ball" legged chairs, with finely carved "shell and ribband" knee joints. In the armchairs the arms often end in lions' or goats' heads, dolphins or dragons, or curved endive scrollwork. (Fine examples are to be seen at Sir John Soane's Museum, where are eight chairs, the splats inlaid with mother-o'-pearl; Tallow Chandlers' Hall, where are thirty-six chairs, with fluted legs; and South Kensington Museum, which contains some thirty specimens—bedstead, mantelpieces, tables, armchairs, chairs, and firescreens.) Fraudulent arms have been added to many of Chippendale's chairs; these may be recognised by the almost straight designs, which should be finely shaped and gracefully curving. The term Chippendale furniture has now an elastic significance, being applied to any furniture in the peculiar styles of the "Director," or even of the eighteenth century generally. *See also* SHERATON.



CHIPPENDALE CHAIR (BACK).

Chipping Chisel (*Eng.*) A COLD CHISEL (*q.v.*)

Chiretta. *Ophelia chirata* (order, *Gentianaceæ*). The dried plant is imported from India and used in medicine as a bitter tonic.

Chisel. An iron or steel tool with sharp bevelled edge, used in many trades.

Chiton (*Cost.*) The undergarment or vest which was worn both by men and women in ancient Greece.

Chittagong Wood. *See* WOODS.

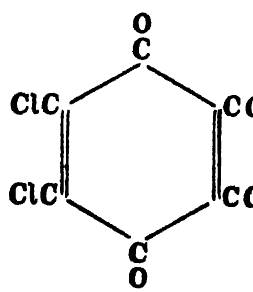
Chladni's Figures (*Sound*). Figures formed on a flat plate when dust, sand, or any fine powder is scattered on it, and it is set in vibration by a violin bow applied to its edge. The dust collects along the lines of least vibration, or NODAL LINES (*q.v.*)

Chlamys (*Cost.*) A cloak worn in ancient Greece. It was oblong in form, and the usual method of wearing it was to arrange one of the shorter sides round the neck, fastening the ends on the right shoulder by means of a clasp, thus allowing the garment to hang down in front and at the back.

Chloral *or* **Trichloracetaldehyde** (*Chem.*), CCl_3CHO. A colourless, oily, pungent-smelling liquid; boils at 97°. It has the reactions of an ALDEHYDE (*q.v.*) Treated with alkalis, it yields chloroform and a formate, $CCl_3CHO + NaOH = CCl_3H + HCOONa$. With water it forms a well crystallised solid, CHLORAL HYDRATE (*q.v.*) It is prepared by passing chlorine into alcohol in the cold at first; then, when the chlorine is less readily absorbed, in heat. The product so obtained is CHLORAL ALCOHOLATE, $CCl_3CH\left\langle\begin{matrix}OH\\OC_2H_5\end{matrix}\right.$, and the operation lasts about a fortnight. This substance is decomposed by sulphuric acid, setting free chloral, which can be separated and purified by distillation.

Chloral Hydrate (*Chem.*), $CCl_3CH\left\langle\begin{matrix}OH\\OH\end{matrix}\right.$. Forms colourless prismatic crystals; has a smell resembling that of a melon; decomposed by heat into its constituents, water and chloral. It is made by adding the proper amount of water to chloral and allowing to crystallise. It is extensively used as a hypnotic (sleep producing) agent, but it is a powerful poison.

Chloranil *or* **Tetrachlorquinone** (*Chem.*) Yellow crystalline plates which sublime without melting. It results from many benzene derivatives, such as phenol and aniline, when they are simultaneously chlorinated and oxidised, as, for example, by hydrochloric acid and potassium chlorate. It is used as an oxidising agent in the preparation of a number of dyes.



CHLORANIL.

Chlorates (*Chem.*) Salts of CHLORIC ACID, $HClO_3$ (*q.v.*) All chlorates are soluble in water; on heating, they evolve oxygen and a trace of chlorine, leaving a

chloride behind. The most important chlorates are those of potassium, sodium, barium. *See* POTASSIUM *and* SODIUM COMPOUNDS.

Chlorhydrins (*Chem.*) Chlorides of dihydric, trihydric, etc., alcohols. Thus ethylene chlorhydrin,

$$\begin{array}{l} CH_2Cl \\ | \\ CH_2OH \end{array}$$

is derived from the dihydric alcohol glycol,

$$\begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array}$$

by the replacement of one hydroxyl group by chlorine.

Chloric Acid (*Chem.*), $HClO_3$. Is only known in solution in water. The solution has a pungent smell, and is a powerful oxidising agent which sets fire to many organic bodies, such as paper or wood; it may be obtained by adding the calculated quantity of sulphuric acid to a solution of barium chlorate.

Chloride of Lime (*Chem.*) *See* BLEACHING POWDER.

Chlorides (*Chem.*) Are (1) compounds of elements with chlorine; (2) compounds of alcohol radicals (an alcohol minus the OH group or groups) with chlorine; (3) compounds of acid radicals (an acid minus the OH group or groups); (4) compounds of certain other radicals with chlorine. In this article only the first of the above groups is dealt with; the other chlorides will be dealt with individually. The chlorides of the non-metallic elements are gases or liquids, and most of them are decomposed by water, giving acids; they are not salts. The metallic chlorides are liquids, or solids; a few (those of antimony and bismuth, for example) are decomposed by water, giving OXYCHLORIDES, while the rest are not decomposed by water, most of them being dissolved by it—only silver and mercurous chlorides being practically insoluble in water. Chlorides may be obtained: (1) by direct union of the elements; (2) in case of many metals by solution of the metal, its oxide, hydroxide, or carbonate in hydrochloric acid; (3) by double decomposition—*e.g.* the chlorides of lead and silver and mercurous chloride by adding a soluble chloride to a solution of the corresponding nitrate; (4) those of boron, silicon, aluminium, and chromium by passing dry chlorine over a strongly heated mixture of the oxide and carbon.

Chlorine, Cl. Atomic weight, 35·45. A greenish-yellow gas with powerfully irritating smell; very heavy (2·5 times as heavy as air); soluble in water (1 vol. water at the ordinary temperature and pressure dissolves 2·5 vols. of chlorine). Below 10° the saturated solution deposits crystals of a hydrate, $Cl_2 8H_2O$. This gas was the first to be liquefied, as the operation is easily effected. It unites directly with most elements, forming chlorides. Phosphorus and arsenic and some other substances burn in it. Water is decomposed by it under the influence of light, forming hydrochloric and hypochlorous acids. It reacts with most organic compounds, either displacing hydrogen or adding itself directly to the compound, or in a few cases setting free the carbon: *e.g.* acetic acid, CH_3COOH, gives monochloracetic acid, $CH_2ClCOOH$; ethylene, C_2H_4, gives ethylene chloride, $C_2H_4Cl_2$. Some hydrocarbons treated with an excess of chlorine in bright sunlight give carbon and hydrochloric acid gas; such are marsh gas, (CH_4), and ethylene, (C_2H_4), while turpentine gives the same result without sunlight. The gas can be obtained by heating manganese dioxide with hydrochloric acid or any other peroxide; also by heating potassium permanganate or dichromate with the same acid; also by acting on bleaching powder (*q.v.*) with an acid, and in many other ways. *See* DEACON'S PROCESS. The principal uses of chlorine are: (1) In bleaching (*q.v.*) it bleaches in virtue of its action on water: $Cl_2 + H_2O = 2HCl + O$, the oxygen liberated being the effective agent—oxidising the colour to a colourless compound. (2) In the extraction of gold. (3) In the preparation of many important organic compounds. *See* CHLORAL HYDRATE. (4) As a disinfectant. It is best applied for room disinfection by washing the walls with a 1 per cent. solution; the washing should be repeated two or three times. A preparation known as "Chloros," which contains 10 per cent. of chlorine, is also a good disinfectant.

Chlorine Carriers (*Chem.*) Iodine, the pentachlorides of antimony and molybdenum, ferric chloride, all in dry state, have the power of greatly accelerating the action of chlorine on certain carbon compounds; they are called chlorine carriers. Carbon disulphide is readily converted into the tetrachloride by chlorine in presence of antimony pentasulphide. Nitrobenzene readily gives metachlornitrobenzene when treated with chlorine in presence of ferric chloride; without the ferric chloride there is no action at all.

Chlorine Monoxide (*Chem.*), Cl_2O. A yellow gas with irritating smell: explodes on heating, also on contact with organic matter such as sugar or turpentine. Its solution in water forms HYPOCHLOROUS ACID (*q.v.*) It is obtained by passing chlorine over cold dry yellow mercuric oxide.

Chlorine Peroxide (*Chem.*), ClO_2. A yellow gas with perfectly characteristic smell; readily explodes on heating and on contact with organic matter; very soluble in water. Obtained by very cautiously heating potassium chlorate with sulphuric acid; also obtained, mixed with chlorine, by the action of hydrochloric acid on potassium chlorate.

Chlorite Schist (*Geol.*) Usually a dynamically formed rock whose parent mass was one containing a large proportion of one or more of the FERRO-MAGNESIAN SILICATES (generally an amphibole). Percolating waters have changed the composition of these latter, and the differential movement of parts of the rock mass caused by earth-creep has given rise to the SCHISTOSE STRUCTURE (*q.v.*)

Chlorite Slate (*Geol.*) Slates coloured pale green by iron in the ferrous condition are often spoken of under this name. Most of the rock now remaining which has been called "Chlorite Slate" is really Chlorite Schist (*q.v.*)

Chloro Derivatives (*Chem.*) These are the chlorine substitution products of organic compounds, *e.g.* CHLOROBENZENE, C_6H_5Cl, is derived from benzene by replacement of an atom of hydrogen by an atom of chlorine. *See* BROMO DERIVATIVES.

Chloroform *or* **Trichlormethane** (*Chem.*), $CHCl_3$. A heavy, colourless, sweet-smelling liquid; boils at 61·5°; is slightly soluble in water; an excellent solvent for many organic substances. It is a powerful anæsthetic when inhaled. In presence of air and light it is oxidised to CARBONYL CHLORIDE (*q.v.*), a dangerous gas to inhale; 1 per cent. of alcohol preserves it. Heated with alcoholic potash it yields potassium formate; with alcoholic potash and an amine (*e.g.* aniline) it yields the nauseous-smelling ISOCYANIDES (*q.v.*) This reaction serves as a test. It is obtained from CHLORAL (*q.v.*); also by distilling a mixture of bleaching powder, water and alcohol on a water bath.

Chlorophyll (*Botany*). The green colouring matter of plants. The pigment can be extracted from various leaves, and is used as a delicate colouring agent for perfumes, essences, etc.

Chloroplastid (*Botany*). The agent in assimilation or PHOTO-SYNTHESIS (*q.v.*) It is a protoplasmic body holding a green pigment, chlorophyll (*q.v.*), which by its action upon light supplies the energy needed for assimilation.

Checking (*Mining*). *See* CHOCKS.

Chocks (*Mining*). Supports loosely built in to support the roof of a seam when the coal is removed. The process is called CHOCKING.

Choir (*Architect.*) The part of a church to the east of the nave, and often separated from it by a screen. It is used by the clergy and others assisting in the services, and is also known as the CHANCEL. *See* NAVE.

Choir Organ (*Music*). That part of an organ chiefly used in accompanying the choir in the softer parts of the service, and connected with the lowest keyboard of three-manual organs.

Choke Damp (*Mining*). CARBONIC ACID GAS (*q.v.*)

Choking Coils (*Elect. Eng.*) A coil of insulated wire of low resistance, wound on a core of laminated iron or iron wire; it possesses a large impedance (*q.v.*), and is therefore often called an IMPEDANCE COIL. It is joined up in series in an alternating current circuit to prevent too large a current from flowing through the circuit. These coils serve the same purpose as a resistance does in a continuous current circuit, but do not cause any appreciable waste of power if they are properly designed. The size of the core and the number of turns on the coil are determined in a manner similar to that adopted in designing a TRANSFORMER (*q.v.*)

Cholesterine (*Chem.*), $C_{27}H_{45}OH$. Forms shining crystalline plates; soluble in alcohol, ether, and chloroform. Said to be an alcohol. It occurs in nervous tissue and in bile; gallstones are often composed nearly entirely of it. Its chloroform solution, shaken with concentrated sulphuric acid, turns red, then violet, while the acid acquires a green fluorescence.

Choline (*Chem.*), $N\begin{cases}CH_2CH_2OH\\CH_3\\CH_3\\CH_3\\OH\end{cases}$

(*Oxyethyltrimethylammonium hydroxide*). A thick liquid (crystallises with difficulty), very soluble in water; it has a bitter taste. It is a powerful alkali, forming salts with acids—even carbonic acid. It is a PTOMAINE (*q.v.*), and is found in decaying corpses, also in pure cultures of the cholera bacillus. It is not very poisonous, being similar in its action to MUSCARINE (*q.v.*), but in much smaller degree. It is a splitting product of lecithin, a substance found in all nervous tissue. It has been made artificially by the union of ethylene chlorhydrin (*see* CHLORHYDRINS) and TRIMETHYLAMINE (*q.v.*)

Chopine (*Cost.*) A high wooden clog or patten worn on the feet. Chopines were worn in England during the fifteenth and sixteenth centuries, being introduced from Venice, where, among ladies, the height was regulated by the rank of the wearer.

Choragic Monument (*Architect.*) A monument erected in honour of the victorious Choragus (*q.v.*) in a Greek choral competition. The Choragic monument of Lysicrates at Athens is a fine example.

Choragium (*Archæol.*) The apartment where the chorus was trained in a Greek or Roman theatre, or the space where the choral dance was performed.

Choragus, Choregus (*Archæol.*) (1) In ancient Greece the leader or superintendent of the chorus. (2) The title of a functionary connected with musical studies in the University of Oxford.

Chord (*Geom.*) A straight line which joins the extremities of an arc of a circle or other curve.

—— (*Music*). Two or more notes sounded together.

Chorus. In ancient Greece a band of singers and dancers who performed at festivals and in the drama.

Chromate of Lead (*Min.*) A synonym for CROCOISITE (*q.v.*)

Chromates (*Chem.*) Salts of chromic acid, (H_2CrO_4). *See* POTASSIUM CHROMATE *and* DICHROMATE, *under* POTASSIUM COMPOUNDS; *and* LEAD CHROMATE, *under* LEAD COMPOUNDS.

Chromatic Aberration (*Light*). Since the focal length of a lens depends on the index of refraction (*q.v.*) of the glass, it follows that there will in general be different foci for light of different wave lengths. Thus an ordinary simple lens will have a focus for violet rays which may be separated by a considerable distance from the focus of the red rays, while the foci of the remaining colours of the spectrum will be between these two points. This dispersion or separation of colours is termed chromatic aberration. It may be corrected by combining two or more lenses, forming an ACHROMATIC LENS or COMBINATION. The commonest form consists of a convex lens of crown glass and a concave lens of flint glass placed in contact. Such a combination can be made achromatic for two colours only—*e.g.* it may bring red and violet rays to a common focus; but if we required rays of a third colour to be brought to the same focus, we should require a third lens. In practice, lenses required for visual purposes are usually achromatised for rays in the orange-red and the green-blue parts of the spectrum; while lenses required for photography are achromatised for rays near the violet end.

Chromatic Chord (*Music*). A chord having one or more notes foreign to the diatonic scale.

Chromatic Notes (*Music*). Those altered by accidentals.

Chromatics. The theory and science of colours; the branch of optics that treats of the properties of the colours of light and of natural bodies. *See* COLOUR.

Chromatic Scale (*Music*). Consisting entirely of semitones.

Chrome Alum (*Chem.*) *See* CHROMIUM COMPOUNDS.

Chrome Green (*Dec.*) A permanent green consisting of oxide of chromium. *See also* CHROMIUM COMPOUNDS.

Chrome Iron Ore. *See* POTASSIUM DICHROMATE, *under* POTASSIUM COMPOUNDS.

Chrome Leather. Leather of all kinds which has been tanned with chrome salts instead of with vegetable tanning materials.

Chrome Ochre (*Min.*) A clay containing a mixture of the sesqui-oxides of chromium, and occurring in association with CHROMITE (*q.v.*), from the decomposition of which it probably results.

Chrome Red. *See* LEAD CHROMATE, *under* LEAD COMPOUNDS *and* DERBY RED.

Chrome Yellow (*Dec.*) The most useful yellow of the decorator. It consists of chromate of lead, and is made in various shades, such as "primrose" (the lightest), "lemon," "middle," "deep," etc. May be mixed with other pigments, excepting those containing sulphur, such as ultramarine (*q.v.*) and cadmium yellow (*q.v.*)

Chromite (*Min.*) A chromate of iron, aluminium, and magnesium $(FeO,MgO)(Cr_2O_3, Al_2O_3)$, containing 40 to 64 per cent. of Cr_2O_3: cubic: occurring in iron-black octahedra in serpentine, a metamorphosed ultrabasic rock. The PORPHYR VERDE ANTIQUE owes its green colour to disseminated chromite. Found in the Urals, United States, etc.

Chromium, Cr. Atomic weight, 52·1. A hard white metal: less fusible than platinum: oxidised in moist air: dissolved by hot dilute hydrochloric and sulphuric acids, forming corresponding chromous salts: slowly attacked by dilute nitric acid: obtained by heating chromic oxide with carbon in the electric furnace, and again heating the product in succession with chromic oxide, with quick lime, and finally with the double oxide of chromium and calcium obtained in the last process as a by-product; also by heating chromic oxide with aluminium powder. *See* GOLDSCHMIDT'S PROCESS. Alloyed with iron (1·2 to 1·5 per cent. Cr) it forms CHROMIUM STEEL, used in making projectiles. Chromium does not occur native; it exists in combination in CHROMITE (*q.v.*), CHROME OCHRE, a complex silicate, and SELWYNITE, a similar mineral found in Australia, and in some chromates as CROCOISITE (*q.v.*)

Chromium Compounds (*Chem.*) Chromium acts as a basic element, forming two classes of salts (chromous salts and chromic salts), and also as an acidic element forming an acid oxide (chromium trioxide). The CHROMOUS SALTS resemble the ferrous salts in constitution and behaviour; *e.g.* they are strong reducing agents, and dissolve nitric oxide. CHROMIC OXIDE, Cr_2O_3, is a dull green powder when made by heating the hydroxide or a mixture of potassium dichromate and ammonium chloride; a brighter green when made by heating mercurous chromate. It is a basic oxide. Heated with alkalies in presence of air or an oxidising agent, it gives chromates, $2K_2CO_3 + Cr_2O_3 + 3O = 2K_2CrO_4 + 2CO_2$. Used as a pigment, chrome green, and in colouring glass and porcelain. CHROMIC HYDROXIDE: A grey-green precipitate formed by adding an alkali or alkaline sulphide to a soluble chromic salt. CHROMIC CHLORIDE, $CrCl_3$: A peach blossom coloured salt when obtained by passing chlorine over heated mixture of chromic oxide and carbon, insoluble in water; a green crystalline mass when obtained by dissolving the hydroxide in hydrochloric acid and crystallising the solution. CHROMIC SULPHATE: The hydroxide is dissolved in sulphuric acid in the cold, and solution on standing deposits violet blue crystals, which, heated with sulphuric acid, give red anhydrous chromic sulphate, $Cr_2(SO_4)_3$. The violet solution turns green on heating, owing to formation of basic salts. It forms alums (*q.v.*) CHROME ALUM, $K_2SO_4Cr_2(SO_4)_3 24H_2O$: Dark purple octahedra, red by transmitted light. Solution is dichroic (red green), and turns green, like the sulphate, on heating. Obtained by reduction of a mixture of potassium dichromate and sulphuric acid by sulphur dioxide or alcohol. Used in dyeing and calico printing. CHROMIC TRIOXIDE, CrO_3: Lustrous red prisms, very soluble in water; the solution behaves as an acid, chromic acid, $CrO_3 + H_2O = H_2CrO_4$. It is a powerful oxidising agent. Obtained by adding sulphuric acid to cold concentrated solution of potassium dichromate. CHROMYL CHLORIDE, CrO_2Cl_2: A dark red liquid boiling at 118°. With water forms chromic and hydrochloric acids. It converts methyl groups of aromatic hydrocarbons into aldehyde groups (Etard's reaction); *e.g.* toluene (*q.v.*) to benzaldehyde (*q.v.*)

Chromo Lithography. *See* LITHOGRAPHY.

Chromo Sensitive Material (*Photo.*) *See* PHOTOGRAPHY IN COLOURS.

Chromo Xylography. *See* ENGRAVING: CHROMO XYLOGRAPHY.

Chromyl Chloride. *See* CHROMIUM COMPOUNDS.

Chronograph. A registering timepiece, usually having a start, stop, and flyback seconds hand.

Chronoisothermal Curves (*Meteorol.*) Curves showing the hour of the day at which the average temperature at some given point on the earth's surface has the same value at different times of the year.

Chronometer. A finely made timepiece, with a balance wheel specially adjusted to ensure the keeping of correct time when the temperature varies. It also has a "dedent" escapement. For marine use the instrument is suspended in "gimbals," or slings, to preserve it from vibration and to keep it, as far as possible, horizontal.

Chryselephantine (*Archæol.*) A term applied to works of sculpture overlaid with ivory and gold, *e.g.* the statue of Athene by Pheidias.

Chrysene (*Chem.*), $\begin{array}{l} C_6H_4 - CH \\ \vert \\ C_1 \end{array}$

Forms white leafy crystals with violet fluorescence: melts at 250°. It occurs in the highest boiling portions of coal-tar.

Chrysoberyl (*Min.*) Beryllium aluminate, $BeO.Al_2O_3$. Alumina = 80·2, berylla = 19·8 per cent. It occurs in rhombic prisms of various shades of green. Its hardness = 8·5. It is cut as a gem. Found in the Mourne Mountains in Ireland, in Ceylon, Brazil, the Urals, United States, etc.

Chrysocolla (*Min.*) A hydrous silicate of copper, $CuSiO_3 . 2H_2O$. Oxide of copper = 28 to 45, silica = 26 to 40, water = 16 to 31 per cent. As an ore it only yields up to about 10 per cent. of copper. It is used as an ornamental stone. The colour varies in different shades of blue and green, perhaps due to colouring by impurities. Found in Cumberland, Westmoreland, Cornwall, Dumfriesshire, Saxony, Australia, etc.

Chrysoidine (*Chem.*) $C_6H_5-N=N-C_6H_3(NH_2)_2$ HCl (1 : 2 : 4). Shining black crystals, greenish by reflected light. It is a dye used for orange shades on wool, silk, and cotton mordanted with tannin. Prepared by action of diazobenzene chloride (*see* 'DIAZO' COMPOUNDS) on metaphenylene diamine (*q.v.*) *See also* DYES AND DYEING.

Chrysolite (*Min.*) A silicate of magnesium and iron, $2(MgFe)O . SiO_2$. Rhombic. Colour, pale green and transparent to dark green and translucent. The term is rather confined to the transparent variety, OLIVINE being used as a more general term. Olivine

is a common constituent of basic eruptive rocks. Chrysolite is cut as a gem. The best chrysolite comes from the Levant.

Chrysophenin. *See* DYES AND DYEING.

Chrysoprase (*Min.*) A green variety of CHALCEDONY (*q.v.*), semitranslucent; coloured by nickel oxide. It is cut for jewellery, and is supposed to bring the wearer good luck.

Chrysotile (*Min.*) A fine fibrous variety of SERPENTINE (*q.v.*), usually of rich yellow green colour, and of a silky lustre. It is sometimes used as an ornamental stone.

Chuck. (*Eng.*) A device for holding work on the mandrel of a lathe or for holding small drills. There are very many forms. *See* CUP CHUCK, DIE CHUCK, SELF-CENTRING CHUCK, *etc.*

Chuffs (*Build.*) Bricks full of cracks, caused by rain falling on them when being burnt.

Church Bells (*Her.*) Represented in perspective, the clapper visible below the rim of the bell and the shank visible at the top.

Chute *or* **Shoot** (*Mining*). An inclined shaft through which minerals are allowed to fall to a lower level: the term is also applied to channels carrying water, etc.

Chyle (*Zoology*). The milky fluid, containing fats, found in the lacteal vessels in the walls of the small intestine. *See* VILLI. The fats are formed from the fatty bodies absorbed from the CHYME.

Chyme (*Zoology*). The semi-liquid mass of food, mixed with gastric juice and peptones, after passing through the stomach.

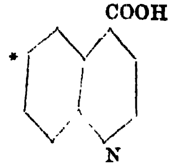
Ciborium. (1) A chalice or cup with a cover for holding the consecrated bread or host. (2) The PYX (*q.v.*) (3) The tabernacle for holding the pyx. (4) A portable altar. (5) A receptacle for relics. *See also* BALDACHINO.

C.I.F. (*Cotton*). A system of direct shipment to spinner by which the purchaser is allowed 6 per cent. and free Carriage, Insurance, and Freight.

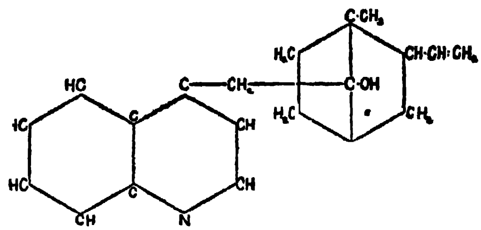
Cimbalo. *See* MUSICAL INSTRUMENTS: STRING.

Cinchona (*Botany*). A genus of the order *Rubiaceæ*, of economic importance as the source of PERUVIAN BARK. *C. succiruba* produces the red bark; *C. calisaya*, the yellow variety; *C. officinalis*, the brown variety. *See also* QUININE.

Cinchonine (*Chem.*) An alkaloid closely related chemically to quinine (*see* QUININE), but not having its valuable medicinal properties: it differs also from it in not giving a green colour with chlorine water and ammonia and in not yielding fluorescent salts. It occurs in cinchona bark along with quinine and many related alkaloids (about thirty); and it is separated from quinine by making use of the facts: (1) that its sulphate is more soluble than that of quinine; (2) that the alkaloid is less soluble in alcohol and in ether than quinine. It is a white crystalline solid (prisms); begins to sublime at 220° and melts at 254°: bitter taste: very slightly soluble in water. Unlike the majority of alkaloids, its alcoholic solution is dextrorotatory. It is a strong diacid base, and so forms two series of salts. It is easily transformed into a number of isomeric alkaloids; *e.g.* by boiling it with acetic acid it yields a far more poisonous isomeric alkaloid, cinchotoxin or cinchonicin. The following facts are very important in relation to the constitution of this alkaloid and the closely related quinine (methoxy-cinchonine). It is a ditertiary base. *See* TERTIARY BASES. It is an alcohol, as it unites with acid chlorides to form esters. It is an unsaturated compound (*q.v.*), as it adds on two atoms of bromine. It is a quinoline derivative, as on oxidation with chromic acid it yields γ-quinoline carboxylic acid. By a somewhat complex series of reactions cinchonine has been converted into lepidine (γ-methylquinoline) and a substance, meroquinine, which is a pyridine derivative. On these and other grounds the following formula has been suggested for cinchonine:



Cinchonic acid.



Quinine only differs from cinchonine chemically in having a methoxy group, (OCH_3), instead of H, in the places marked with an asterisk in the above formulæ.

Cinctures (*Architect.*) The annulets on the shaft of a column immediately above the base and below the astragal of the capital. The projecting blocks which sometimes form part of the shaft of a column are also known as cinctures.

Cinder Pig (*Metallurgy*). A poor variety of pig iron obtained by resmelting slags which are somewhat rich in iron.

Cinder Tap (*Met.*) The slag from puddling or re-heating furnaces.

Cinder Tub (*Met.*) A shallow iron truck with movable sides, into which blast furnace slag is run.

Cinematograph. The common name for apparatus for the production and exhibition in *rapid sequence* of a series of photographs of moving objects, creating the illusion known as "living pictures" or "animated photographs." Special forms of the apparatus are given other names for trade purposes, as the BIOGRAPH, which is probably the largest and best manufactured at present. The illusion depends on persistence of vision, each single picture remaining impressed on the retina till the following one appears. The instrument is a development of the Zoëtrope and was made possible by the introduction of flexible film into photography, to take the place of glass plates. Edison perceived the possibility of moving a long narrow strip of sensitive film along the focal plane of a small camera, and automatically exposing it to the image formed there by the lens, and after some experiment he introduced his "Kinetiscope," about 1894. His method of moving the film is still employed, but in other respects the apparatus has been greatly improved. The instrument consists of a small camera provided with light-tight chambers above and below, and with mechanism for moving the film and working the shutter of the lens. The long strip of film wound on a drum is placed in one chamber, one end is passed into the camera and along its focal plane to

an empty drum in the other chamber, the sensitive surface, of course, facing the lens. On turning a handle, the mechanism pulls down a portion of the film exactly the size for the picture, opens the shutter of the lens, and closes it again, and goes on repeating these operations in the same order at the rate of from twenty-five to fifty times a second, the film remaining stationary for the fraction of a second required for the exposure of each separate picture. In the larger and heavier instruments the motive power is supplied by an electric motor. The film thus exposed in the camera gives a series of very small negative pictures when developed, and from it a positive film must be printed for exhibition. These films are pulled through the apparatus by means of perforations along the edge, and the perforations in the positive must exactly coincide with those in the negative film. The same or similar apparatus, fixed in front of the condenser of a powerful magic lantern, is used for exhibition and worked in the same way. When exhibited, the same pictures are sometimes magnified nearly 15,000 times, and 1,200 pictures are stopped and moved on in a minute. In order to give a correct record of the scene depicted, the pictures should be exhibited at the same speed as they were taken, but they are usually exhibited somewhat quicker.

Cinerary Urn (*Archæol.*) A sepulchral urn for holding the ashes of bodies which have been burned. There are many examples in the British Museum.

Cinnabar (*Min.*) Sulphide of mercury, HgS. Mercury = 86·2, sulphur = 13·8 per cent. It occurs in deep red highly refractile rhombohedral crystals, and massive in darker red shaly masses. It is the chief source of mercury. The pigment VERMILION is prepared from it. Found in Idria, Almaden, etc., in Spain; Hungary, Mexico, Peru, California, Japan, etc.

Cinnamic Acid (*Chem.*), $C_6H_5CH:CH.COOH$. β-phenylacrylic acid. White needles or prisms: melts at 133°: slightly soluble in cold, readily in hot water. It is an unsaturated compound (*q.v.*), and takes up two atoms of bromine: formerly important in the synthesis of indigo: occurs in storax and a number of balsams: obtained artificially by acting upon benzaldehyde (*q.v.*) with sodium acetate and acetic anhydride (Perkin's reaction), $C_6H_5CHO + CH_3COONa = C_6H_5CH:CH.COONa + H_2O$. There are two unstable modifications of it—allocinnamic and isocinnamic acids. *See* STEREOISOMERISM.

Cinnamon. The drug and spice is the dried inner portion of the bark of the young branches of *Cinnamomum zeylanicum* (order, *Lauraceæ*).

Cinnamon Stone (*Min.*) One of the calcium Aluminium GARNETS (*q.v.*), often also called HYACINTH; it is an orthosilicate of calcium and aluminium, with the iron in the ferric state. The exact composition varies. The colour is yellow to brown. The hardness is slightly greater than that of quartz. Used as jewellery. It crystallises in forms of the cubic system. Localities are: Aberdeenshire, Wicklow, Ceylon, etc.

Cinquecento. Literally 500, but used as an abbreviation of "mille cinquecento," 1500. A term applied in Italy to the sixteenth century, the period when art revived and classical influence was paramount. It is also applied to decorative art and architecture characterised by the reversion to classical forms that commenced about 1500. The term is often applied incorrectly to ornament of the sixteenth century in general.

Cinquefoil (*Architect.*) An opening in Gothic tracery formed with five foils or spaces between cusps. *See also* FOILS, CUSPS, TREFOIL, QUATREFOIL, *and* MULTIFOIL.

Cipher. (1) The symbol 0, which denotes zero. (2) A cryptographic mark or device. Sometimes it takes the form of a monogram.

Cipolin. A white marble with green streaks.

Cippus (*Archæol.*) A small column or pedestal, generally rectangular, forming a sepulchral monument. It either contained the ashes of the deceased or marked the place of burial, and frequently bore an inscription. Cippi were also employed by the ancients as memorials of remarkable events, and as landmarks.

Circle. In geometry, a plane figure bounded by a single curved line, called the circumference, every point on which is equidistant from a certain point within, termed the CENTRE.

—— (*Lace Manufac.*) That portion of a twist lace machine where all the most delicate parts of the mechanism are situate. The centre of the circle is the point where the formation of the lace becomes perceptible. All the movements of the threads necessary for its formation take place in the lower portion of its circumference.

Circle of Curvature. A circle drawn from the centre of curvature of a curve, with radius equal to the length of the normal from that point to the curve, is called the "Circle of Curvature" of the curve for the point where it is cut by the normal. This circle of curvature may be regarded as the circle whose curvature coincides with that of the curve at the point where they touch.

Circle of Reference. *See* HARMONIC MOTION.

Circle on Circle (*Carp. and Join., etc.*) A piece of work which is curved both in plan and elevation: work of double curvature. A door or window with a round (arched) top, situate in a round building, is an example.

Circular Measure. The circular measure of an angle is the ratio of the arc of a circle, bounded by the two lines forming the angle, and having its centre at the apex, to the radius with which the arc is described. The circular measure of an angle of 180° is π, of 90°, $\frac{\pi}{2}$, and an angle whose circular measure is unity contains $\frac{180°}{\pi}$, or 57·296° very nearly. This angle is termed a RADIAN.

Circular Mitre (*Carp. and Join.*) The intersection of a straight and curved moulding of the same section.

Circular Plane (*Carp., Pattern Making*). A plane for working concave or convex surfaces. A modern form, made of iron, has a thin steel sole which can be bent into a circular arc of any required radius (within certain limits), to work on both concave and convex surfaces.

Circular Polarisation (*Light*) *See* POLARISATION.

Circular Saw. A saw in the form of a steel disc: used for *rapid* and heavy sawing in woodworking; also for metal, in which case the saw is made of much thicker steel and the teeth are formed more like the teeth of a milling cutter (*q.v.*)

Circulating Pump (*Eng.*) The pump used to keep cold water flowing through the CONDENSER (*q.v.*) of a steam or other engine.

Circulation in Boilers, etc. (*Eng.*) The movement of water in boilers, etc., due to connection currents set up by the fall in density of the heated water. It is promoted in boilers by a proper arrangement of water tubes and by keeping the water as much as possible above the heating surfaces. In condensers, pumps are necessary to keep up the circulation.

Circulation of Water (*Motor Cars*). In petrol cars a flow of water from a tank is maintained round the water jacket of the cylinder (*q.v.*) through a radiator or condenser (*q.v.*), the water returning to the tank. This keeps the engine cool, and prevents injury to the cylinder, as well as loss of power, which always occurs if the cylinder become overheated.

Circumferenter (*Surveying*). A form of MINERS' DIAL (*q.v.*) adapted for surveying with the fixed or "fast" compass needle. Also called the ROCK DIAL. It consists of a graduated horizontal circle, provided with a vernier and sights, and a compass needle suspended at the centre of the circle.

Circumflex Accent (*Typog.*) A mark placed over a letter thus, ê.

Circumpolar Star (*Astron.*) A star always above the horizon, *i.e.* one whose angular distance from the celestial pole is less than the terrestrial latitude of the place of observation.

Circus (*Archæol.*) A large oblong building used by the Romans for horse racing, chariot racing, gladiatorial contests, etc., which took place in the arena. Around the building rose tiers of seats for the spectators. The Romans seem to have established circuses wherever they settled.

Cire Perdue. *See* LOST WAX.

Cirque (*Geol.*) A name usually given to some geographical features occurring near the heads of valleys in districts that have been heavily glaciated. The features in question are shaped like a bowl which has been cut in halves from top to bottom. In some few cases such a feature may really be due to the conjoined action of several adjacent streams; but it is now recognised as being more generally due to the erosive action of ice, to which local circumstances have imparted a slow rotatory or eddying movement.

Cirro-Cumulus (*Meteorol.*) *See* CLOUDS.

Cirrus (*Meteorol.*) *See* CLOUDS.

Cissing (*Dec.*) A fault in a varnished surface in which small dull spots appear. Usually caused either by minute holes or grease spots. Remedy: thoroughly clean and rub down surface and re-varnish.

Cist *or* **Kist** (*Archæol.*) A stone coffin of prehistoric times formed by two parallel rows of slabs placed on edge, with one or more slabs placed horizontally across them. Sometimes the cist was excavated in the solid rock or formed in a tree trunk. *See also* CISTA.

Cista (*Archæol.*) The name given to a small box containing sacred objects, carried at the festivals of Demeter and Dionysus. (2) The ballot box used in the Roman comitia.

Cistern Barometer. *See* BAROMETER.

Cistern Pump. *See* FORCE PUMP.

Cisterns (*Hygiene, etc.*) Where the water supply of a town is on the intermittent principle, cisterns are necessary for the storage of water. They should be fixed in a well ventilated place, regularly cleansed, properly covered, and constructed of a material that will not impart any impurity to the water. It is extremely important to see that no communication exists between the cistern supplying the water closet and the storage cistern.

Cithara. An ancient musical instrument with from seven to eleven strings, somewhat like the lyre in shape. The modern zither is also derived from it, and preserves much the same form.

Citric Acid (*Chem.*), $CH_2COOH.COHCOOH.CH_2COOH$. Large colourless crystals: melts at 153°: readily soluble in water and in alcohol. It occurs free in a large number of fruits, and is obtained from lemon juice by precipitating the citric acid in it as calcium citrate (the precipitate only forms on heating), and decomposing this salt with sulphuric acid. This acid has been prepared artificially. It is much used in making effervescing drinks and to impart an acid flavour (*e.g.* to jellies).

Citrine (*Min.*) Quartz of a clear yellow colour; also called YELLOW TOPAZ.

Citron. *See* CITRUS.

Citronella Oil. An oil used in perfumery, distilled from a species of grass, *Andropogon nardus* (order, *Gramineæ*), extensively grown in Singapore.

Citrus (*Botany*). A genus of the order *Rutaceæ*, noted for the economic importance of its species and varieties. *C. medica* is the citron, whose variety *Limonum* is the lemon, *Limetta*, the sweet lime. *C. aurantium*, the orange, has two varieties—*Bergamia*, the Bergamot, and *Bigaradia*, the Seville orange.

City Solder. Solder stamped by the Worshipful Company of Plumbers.

Civil Engineering. The branch of engineering dealing with railways, roads, docks, harbours, waterworks, and many other branches of construction, but excluding mechanical and electrical appliances.

Cl (*Chem.*) Symbol for CHLORINE (*q.v.*)

Clack *or* **Clack Valve** (*Eng.*) The flap or hinged valve of a suction pump.

Clairecolle *or* **Clearcole** (*Dec.*) An undercoat of size employed on plaster surfaces to stop suction and form a ground for distemper. Made from glue, size, or concentrated size powder mixed with whiting and water.

Clam. Clamp (*Eng.*) Pieces of wood or soft metal (such as lead) fitted to the jaws of a vice for holding polished or delicate objects without injury.

Clamp (*Brickmaking*). A clamp is a stack of raw bricks, with cinders intermixed, to assist in their complete burning. *See also* BRICKS.

—— (*Eng., Carp., etc.*) An appliance used for gripping a piece of work in order to force its parts into close contact; the requisite pressure is usually applied by means of a screw.

Clamp Bricks. Bricks that have been burnt in a clamp; they are also known as STOCK BRICKS. *See also* BRICKS.

Clamping Screw (*Eng.*) Any screw for holding a detachable tool or part of a machine in place.

Clarendon (*Typog.*) A bold-faced condensed type, generally used in dictionaries. The TERMS in this work are printed in clarendon type.

Clarinet *or* **Clarionet.** *See* MUSICAL INSTRUMENTS: WIND (WOOD).

Clark Cell (*Elect.*) The best known form of "Standard Cell" (*q.v.*) Its positive pole is a platinum wire dipping into mercury. Above the mercury is a paste of mercurous sulphate; on this floats a saturated solution of zinc sulphate, in which dips a rod of zinc forming the negative pole. The E.M.F. is 1·434 volts at 15° C., falling slightly as the temperature rises.

Clark's Process. The object of this process is to soften water. The hardness of water is due to the presence of salts of lime and magnesia. In Clark's Process lime water is added, and combines with the carbon dioxide; the bi-carbonate of lime is thus rendered insoluble and precipitated. The precipitate carries down with it any suspended matters present in the water. It is only efficacious in removing what is called "temporary hardness." *See also* CALCIUM COMPOUNDS.

Clasp (*Bind.*) A catch formerly used for holding the covers of a book together when closed.

Clasp Nail. A nail used by pattern makers. It has projections from the head which enter the wood as well as the stem or shank of the nail. These projections give the nail a greater hold on the wood than a common nail would afford.

Clasp Nut (*Eng.*) The nut in a slide rest which engages the leading screw (*q.v.*) It can be disengaged at will, as it is cut through longitudinally, so that the two halves can be separated. In some cases only one half is used, and this can be raised out of contact with the screw.

Classical (1) Pertaining to the art, literature, antiquities, etc., of ancient Greece and Rome. (2) Conforming to the styles of the foregoing. (3) Applied to a production, either painting or music, characterised by beauty of form, taste, and restraint.

Classicism. Tendency towards the classical style.

Classification of Elements. *See* PERIODIC SYSTEM.

Clastic Rocks (*Geol.*) A general term for rocks which have been built up from fragments. Thus clay, sand, sandstone, quartzite, gravel, conglomerate, arkose, are all clastic rocks. In cases where the chief fragments are directly of volcanic origin, as in the case of tuff and agglomerate, the resulting rocks are distinguished as PYROCLASTIC.

Claude Glass. Named after Claude Lorraine. A dark or coloured mirror used for reflecting landscapes. They are useful for artists in selecting and composing pictures.

Claus Kiln. *See* CHANCE'S PROCESS.

Claw Coupling *or* **Clutch** (*Eng., etc.*) A pair of flanges on the opposing ends of two shafts, with projections which engage each other when the two flanges are brought together, thus connecting the shafts so that they turn together. This form of clutch enables the shafts to be coupled or uncoupled instantaneously.

Claw Wrench (*Eng.*) A spanner or wrench with one loose hinged jaw, which grips tighter the more the pressure on it increases. A PIPE WRENCH is a form of claw wrench.

Clay (*Geol., etc.*) A clastic or derivative rock consisting essentially of a hydrous silicate of alumina, which is nearly always mixed in variable proportions with sand, lime, iron, or other minerals, or even with organic substances. Dry clay gives forth an argillaceous odour when breathed upon; and when it is moistened with water it is rendered plastic, and can be moulded without subsequently losing its shape. In other respects it varies so much that no general description can be applied to it.

Clay Band. *See* CLAY IRONSTONE.

Clay Cracked (*Pot.*) Ware is described as clay cracked if, when removed from the bisque oven, a crack is found which is traceable to the clay stage of its production.

Clay Ironstone. Nodules or concretionary masses, often of a rudely spherical form, which are composed essentially of a carbonate of iron mixed with more or less argillaceous matter. They usually occur in shales or in clays, and very commonly in close association with carbonaceous matter. Cracks are generally present in the interior of the nodules, and are often lined with calcite. These are then spoken of as SEPTARIA. Clay ironstone is, or was, largely used for the manufacture of iron. Some clay ironstones, also, are used for making hydraulic cement.

Clay Press (*Pot.*) A press used to squeeze the superfluous water from SLIP (*q.v.*), to convert it into clay.

Clay Slate (*Geol.*) An antiquated term which was loosely employed for any metamorphosed argillaceous rock with a tendency to split into thin plates. Under this head were included slates of argillaceous composition, phyllites, graphitic schists, and many other rocks of the same general character which it is now found convenient to distinguish by special names.

Clay Wash (Clay Water) (*Moulding*). Clay greatly diluted with water. In moulding, various objects are coated with a film of moist clay by washing with clay water in cases in which the foundry sand is required to adhere to them.

Cleading (*Eng.*) LAGGING (*q.v.*)

Clean Casting (*Eng.*) One free from faults on the surface or skin.

Clean Cut (*Eng., etc.*) A cut which is smooth and regular, as opposed to one which is ragged or which shows chattering (*q.v.*)

Cleaner (*Eng., etc.*) Applied to various tools; in moulding, a flat-bladed tool used for smoothing the surface of a mould. *See* SLEEKER.

Clean Fire (*Eng., etc.*) One which is burning brightly and is free from cinders, clinkers, and ashes.

Cleaning Eye (*Plumb.*) A brass cap screwed into the bottom of a lead trap. Refuse can be removed from the trap by removing the cap.

Clean Lift (*Moulding*). The withdrawal of a pattern from a mould without injury to the latter.

Clean Timber (*Carp.*) Timber that is free from knots and blemishes.

Clean Water (*Eng.*) Water required for use in boilers is said to be "clean" when it is free from visible impurities; it may, however, contain lime, etc., in solution, and therefore produce a deposit when used in boilers.

Clearance (*Eng.*) (1) The amount of space left between two parts which have to fit or engage together. (2) The space between a piston and the end of the cylinder in an engine when the piston is at the end of its stroke.

Clearcole. *See* CLAIRECOLLE.

Clearing Hole (*Eng.*) One bored out to its full nominal size; distinguished from a tapping hole (*q.v.*), which is bored to a smaller diameter in order that an internal thread may be cut in it.

Clearing Solution (*Photo.*) A solution of alum slightly acidified, in which negatives may be soaked to remove yellow stains produced during development by an alkaline developer.

Clear Oil (*Eng.*) Oil purified till transparent or of a light colour.

Clear Span (*Build.*) The horizontal distance between the abutments of a beam or arch.

Clear Story. *See* CLERESTORY.

Cleat. A wood or metal contrivance on which the free end of a rope, blindcord, etc., is coiled in order to make it fast.

—— (*Carp.*) A piece of wood nailed on the surface of one timber, and acting as a "stop" to assist in supporting another timber which rests upon the first; *e.g.* cleats are nailed on to rafters to support the purlins.

—— (*Mining.*) A cleavage in coal, not parallel to the bedding plane. *See also* COAL.

Cleavage (*Geol.*) A term now restricted to the parallel and usually closely set planes of division with one uniform direction, which have been induced in certain rocks partly under the influence of intense lateral compression. A cleaved rock splits with more or less facility in the direction of the cleavage quite independently of any structural planes originally present in the rock. Most slates were clays and of sedimentary origin; but some excellent slates in the Lake District were originally bedded tuffs, and therefore of volcanic origin. *See* FLAGSTONE, PHYLLITE, SCHIST, etc.

—— (*Min.*) A term used for the planes of more ready division of a mineral, pointing to a weaker cohesion along these planes. Cleavage planes are usually parallel to some crystal plane.

Clef (*Music*). A character representing a fixed sound and giving the name of that sound to the line on which it stands. There are three clefs: C, 𝄡 representing the middle C of the grand stave of eleven lines; G, 𝄞, a fifth above it; F, 𝄢 a fifth below it. *See* STAVE. These are often spoken of as the TENOR, TREBLE, and BASS CLEFS respectively.

Clerestory (*Architect.*) The uppermost division of the nave wall of a church immediately above the triforium or blind story (the space between the vaulting and roof over the aisle, frequently used as a gallery). The clerestory is pierced with windows overlooking the roof of the aisle, and was evidently constructed with the idea of increasing the light in the nave, the aisle windows being usually insufficient.

Cleveland Iron Ore. An important ore of iron occurring in the Jurassic rocks of Cleveland, Yorkshire, and other parts of the kingdom. It consists mostly of LIMONITE, with a variable percentage of iron in the form of MAGNETITE. It is nearly always due to a partial or entire replacement of a calcareous oolite by ferruginous matter imported into the rocks from some source at a higher level.

Cliché (*Photo.*) A term sometimes applied to the "negative" in photography.

—— (*Typog.*) An electro or stereotype plate; especially a metal stereotype of a wood engraving. to print from.

Click (*Eng.*) A small pawl (*q.v.*) or catch of a ratchet wheel.

Clicker (*Typog.*) The compositor who receives copy and distributes it to the other compositors or companionship of whom he has charge.

Clinker (*Eng., etc.*) (1) The residue from a furnace or fire from which practically all the available carbon has been burnt out. It is often partly fused, and resembles slag. (2) A small hard brick used for paving

Clinkering (*Eng.*) The extraction of clinker from a fire.

Clinodiagonal (*Min.*) An axis of the Monosymmetric System inclined to the vertical axis at a definite angle in each mineral of the system, and at right angles to the Orthodiagonal (*q.v.*) *See* SYSTEMS OF CRYSTALLOGRAPHY.

Clinodome (*Min.*) A face parallel to the CLINODIAGONAL (*q.v.*)

Clinograph (*Drawing Office*). An instrument used by draughtsmen when drawing two or more similar angles in succession. It resembles the carpenter's bevel (*q.v.*) in principle, but has the stock and blade of the same thickness, like a footrule, in order that the instrument may lie flat upon the drawing paper. The clinograph is invaluable in graphic calculation in statics, when reciprocal figures have to be drawn. *See* GRAPHIC STATICS.

—— *or* **Clinostat** (*Surveying*). An instrument used for detecting deflections from the vertical in a bore hole; it measures and automatically registers the amount of the deflection.

Clinometer (*Surveying*). Any instrument for measuring vertical angles. There are many different forms adapted to various circumstances.

Clip (*Build.*) A slip of lead or copper to prevent slates or tiles from slipping on a roof.

Clip Drum: Clip Pulley (*Eng.*) A pulley with some form of movable clips in the rim. These grip the rope passing between them, thus preventing it from slipping over the pulley. Used for hauling in mines, etc.

Clipeus (*Armour*). A round shield carried by Greek and Roman soldiers, made of wickerwork covered with hide, or of beaten bronze. The SCUTUM was oval or oblong.

Cloaca (*Zoology*). A chamber formed by the last portion of the large intestine in the birds, reptiles, amphibia, and many fishes. The cloaca receives the openings of the genital and urinary ducts.

Cloanthite (*Min.*) An arsenide of nickel, $NiAs_2$. Nickel = 28·4, arsenic = 70·34 per cent., with traces

of impurities. Crystallises in tin-white cubes, but is often associated with the pinkish tinge of Cobalt Bloom, as cobalt usually replaces some of the nickel: in fact, a gradation occurs from Cloanthite to SMALTITE (*q.v.*) Found in Cornwall, Saxony, Bohemia, Sweden, Dauphiny, etc.

Clockmaking. *See* WATCH AND CLOCKMAKING.

Clock Stars (*Astron.*) Stars whose times of transit are known; they are observed in order to find the RATE and ERROR (*q.v.*) of an astronomical clock or a chronometer.

Clogging (*Eng.*) The hardening or thickening of lubricating oil. It tends to check, or even stops, the motion of moving parts of machinery.

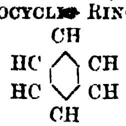
Cloissoné (*Dec.*) Mosaic work in glass or enamels. Japanese cloissoné is a mosaic of enamel on a metal ground. Cloissoné glass consists of two sheets of plain glass, with a design between formed of bent copper strips, the whole of the remaining space being filled in with glass globules of various beautiful colours.

Cloister (*Architect.*) The covered way connecting a cathedral with the refectory, chapter house, etc. It usually forms three sides of the quadrangle or garth, the fourth side being formed by the wall of the south nave of the cathedral, as at Wells.

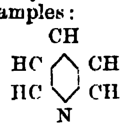
Close (*Architect.*) An enclosure around a large building, such as a cathedral. It is usually surrounded by houses which serve as official residences for the cathedral clergy. In many of the English cathedrals the close adds greatly to the general effect: Salisbury is perhaps the best example.

—— (*Music*). Used in the sense of cadence. "Full close" = perfect cadence; "Half close" = imperfect cadence.

Closed Chain Compounds (*Chem.*) When a number of atoms are joined together in a ring as distinct from a chain, the system is called a closed chain, and its derivatives closed chain compounds. When all the atoms in the ring are alike, the ring is called an ISOCYCLIC, when they are not all alike, a HETEROCYCLIC RING. Examples:



Benzene.



Pyridine.

Closed Coil Armature (*Elect. Eng.*) An armature in which there is a complete path for the current without passing through the External Circuit: the end of one coil or set of turns is joined to the beginning of the next.

Closed Shed (*Cotton Weaving*). The opposite to OPEN SHED. Between each pick inserted in the shed, the tappet, dobby, or Jacquard will allow the heald or harness thread to move to its bottom or central position, and thus close its shed previous to forming another for the next pick of weft. *See* OPEN SHEDDING, SHEDDING.

Closed Stokehold (*Eng.*) *See* FORCED DRAUGHT.

Close Grain. Material the fibres of which are very close together: a purely relative term, incapable of exact definition.

Close Mouth: Closed Mouth (*Eng.*) Applied to punching machines whose jaws are closed at the sides and open at the back and front, thus permitting the passage of narrow bars or rails, but not of sheets of metal.

Closer (*Build.*) A quarter of a brick used for bonding.

Close String (*Carp. and Join.*) In staircase work an outside STRING (*q.v.*) that is not notched out to support the steps.

Closet (*Her.*) A diminutive of the Bar, and one half its width.

Close Test. *See* FLASH POINT.

Close Topped Furnace (*Met.*) A blast furnace (*q.v.*) whose top is closed by a cone. *See also* FURNACES.

Closets, Earth (*Hygiene*). Consist of a wooden box with a receptacle for the excreta below, and a hopper containing dry earth above. When the plug is pulled, the dry earth is thrown on to the sewage. Dry earth is a very powerful deodoriser; the best kinds are dried clay, marl, and loamy soil.

Closing Up (*Eng.*) (1) The formation of the second head of a rivet after it is placed in position. (2) The completion of a foundry mould by placing the uppermost part in its final position.

Cloth (*Woollen Manufac.*) A woven, knitted, or felted structure composed of fibres.

Cloth Binding (*Bind.*) Binding in which the "boards" are covered with prepared calico, plain or embossed with a design.

Clothed (*Her.*) A shield almost covered by a lozenge, but having the corners uncovered.

Clothing: Cleading (*Eng.*) The covering of steam pipes and vessels with non-conducting materials. *See also* LAGGING.

Cloth Red. *See* DYES AND DYEING.

Cloud Negatives (*Photo.*) Separate negatives of clouds, used for printing-in skies in ordinary landscapes in which the whole sky usually appears uniformly bright. They are often taken on flexible films for greater convenience in handling.

Clouds (*Meteorol.*) The visible form assumed by moisture in the atmosphere, identical with MIST. Clouds consist of a great number of minute drops of water. In certain cases these drops may be frozen, so that a cloud may consist of particles of ice. *Forms of Clouds:* Clouds have been classified according to the general form which they present to an observer viewing them from the earth's surface. CIRRUS CLOUDS are feathery streaky clouds formed high up in the air; STRATUS is a form consisting of a sheet of cloud of approximately uniform thickness, occurring low down; CUMULUS is a billowy rounded form, often seen in summer; NIMBUS is the rain cloud, with well defined edges, generally very dark and heavy looking. Meteorologists also use the expressions CIRRO-CUMULUS, CUMULO-STRATUS, etc., to denote combinations of the simple forms. *Formation of Clouds:* It was formerly thought that if air containing water vapour were cooled down, either by sudden expansion or by contact with colder air, till it reached the temperature at which it became saturated, that clouds were necessarily produced. It has been shown, however, that this is not necessarily the case. Aitken and others showed that the presence of particles of dust is of very great importance; in the complete absence of dust the first drops would have a radius comparable with the dimensions of a molecule, and in this case the surface tension of the drops would cause the rate of evaporation to be so great that the drop could not continue to exist. If, however, fine dust particles are present,

the drops are first formed by condensation on the surface of the particles, and the drops thus commence their existence with dimensions so much greater than those of the molecule that the gain in size from condensation more than balances the loss from evaporation. This effect is easily shown by experiment: if damp air from which dust has been entirely removed be suddenly cooled by expansion, no visible condensation will occur; but the admixture of a very small amount of ordinary air, which always contains a great number of dust particles (upwards of 100,000 per cubic inch), will cause a visible cloud to appear when the damp air is allowed to expand suddenly. The researches of Aitken and others led to the belief that dust was always essential to the formation of clouds; but it has since been shown that the presence of gaseous IONS (*q.v.*) in the air is capable of producing the same result. These ions are charged particles, some having charges of negative, others of positive electricity. They may be produced by a variety of agencies—*e.g.* Röntgen, Kathode, and Lenard rays; the radiation from uranium, radium, polonium; by ultra-violet light. Under normal conditions, free ions are always present to some extent in the air, and the number will be increased when the air is exposed to the action of any of the above ionising agencies, and the necessary conditions for condensation and the formation of clouds will be set up.

Cloudy Web (*Cotton Spinning*). Uneven thickness in the sheet or web as it comes from the doffer, caused by defective carding.

Clout Nail. A nail with a large flat head.

Clove. The well known clove is the dried flower bud of an East Indian plant of the *Myrtle* family—*Eugenia caryophyllata*; order, *Myrtaceæ*.

Club (*Her.*) A primitive weapon sometimes used as a charge or placed in the hand of a savage.

Clustered Lotus Bud Capital (*Architect.*) This is one of the capitals used in Egyptian architecture. The column with which it is used represents a bundle of lotus flower stalks banded together at intervals, and the capital is a conventional treatment of a lotus bud, its main lines following those of the stalks in the column. *See* LOTUS FLOWER *and* LOTUS CAPITAL.

Clustered Pillar (*Architect.*) A pillar consisting of several shafts, a common form in Gothic architecture. It usually consisted of a large central pillar, either circular or square, surrounded by smaller shafts. *See* PILLAR *and* MONOSTYLE.

Clutch (*Eng.*) Any device for connecting two pieces of shafting in line, so that they turn together. *See* CLAW CLUTCH, FRICTION CLUTCH, *etc.*

Co. Chemical symbol for cobalt (*q.v.*)

Coach Screw (*Eng., Carp., etc.*) A large screw for heavy timber work, with a square head, which is turned by a spanner instead of by a screwdriver.

Coal. A stratified deposit of compressed and mineralised vegetable matter occurring in the fossil state. Changes have occurred in its chemical composition which have reduced the oxygen originally present to 15 per cent. or less, the relative amount of carbon being consequently increased to 70 per cent. or more. The structure present in the vegetable matter from which coal has been formed is but rarely traceable. Amongst unaltered vegetable products, the nearest approach to coal in respect of chemical composition is to be found in caoutchouc, gums, and resins. Coal presents a wide range in chemical composition, owing to the variable percentage of carbon present and the amount of mineral impurities with which it may happen to be mixed. The percentage of carbon may rise to 90 or more in the best fuel, and may fall to 60 or even less in the varieties which graduate into BROWN COAL and LIGNITE. Furthermore, owing to the fact that coal seams are not homogeneous from top to bottom, but consist of aggregates of thin laminæ, each of which may vary greatly in composition from those above it or below, it follows that different parts of a coal seam at the same spot may have quite different values as fuel. The variation in this latter respect may be still more strongly marked when a comparison is made, of the composition of various examples of the same seam taken from different parts of the coalfield in which the seam occurs. The variation referred to is usually connected with the aggregate percentage of mineral matter, usually clay, that originally entered into the composition of each of the several laminæ of which the coal seam is built up. It may be further affected by the presence of mineral matter, such as pyrites, developed within the seam after the original constituents of the coal were laid down. Three kinds of coal may be observed in each example of most coal seams from strata of Carboniferous age. One of these is quite amorphous, bright, and with a lustrous fracture like the surface of polished jet. This is often referred to as CHERRY COAL. Another kind is also amorphous, gives a conchoidal fracture, and the lustre is dull, like that of clay. This is CANNEL COAL. The third constituent, which is usually present in much smaller proportion, has the general appearance of charcoal, and distinctly shows traces of vegetable structure. It is indeed simply vegetable tissue more or less mineralised. This is a mineral charcoal, often called MOTHER OF COAL. Carboniferous Cherry Coal is largely composed of the resinous spores of lycopodiaceous plants; Cannel Coal represents vegetable tissues which have passed into a pulpy condition through prolonged maceration, while Mineral Charcoal is the representative of such of the vegetable tissues as have been able to resist the change arising from maceration. Another variety of coal, which is of great value as fuel, is known as ANTHRACITE. It contains a high percentage of carbon; is amorphous, heavy, hard; does not soil the fingers; and it gives off little or no smoke when it is being burned. Its peculiarities are due to changes which it has undergone within the Earth's crust; one of the factors concerned in the change appearing to be the presence of water at a high temperature. In the neighbourhood of rocks of an intrusive nature, coal seams have undergone more or less deterioration, and are, in many cases, thus rendered quite valueless. A further cause affecting the commercial value of coal seams is the fact that they tend to graduate horizontally into stratified rocks of other types, useless as fuel. Thus the argillaceous laminæ present in a seam may be small in proportion to the good coal at one place, and yet may show a gradual increase when followed in the direction of a place at no great distance; the change may even proceed so far as to end in a total replacement of the coal seam by carbonaceous shale, of no commercial use. The coal may gradually pass, in like manner, into clay ironstone or into oil shale. The origin of coal seams has been a fertile source of diversity of opinion for a long time. The orthodox view is that it has been

formed on the land as ordinary vegetable growth, when the part of the surface of the Earth where the growth took place has been undergoing intermittent subsidence. Another view, held at present by only a small number of persons, is that, in most cases, coal represents submarine deposits formed off the mouths of the rivers that brought down the vegetable spoils of the land. The salts dissolved in the sea water, and especially the sulphate of lime, are supposed to have been concerned in bringing about some of the chemical changes which have altered the composition of the vegetable substances. The varying powers of resistance to maceration presented by the different vegetable constituents, and the sorting action of water in motion, are sufficient to account for the formation of the layers of different composition. The most essential feature required for the growth of the plants that give rise to extensive beds of coal seems to be a moderately warm and humid climate, which has but a small diurnal and annual range of temperature. Coal occurs in rocks of almost all ages, from those of Carboniferous times—which afford the chief supply of Western Europe—down to others of comparatively recent age. Coal of Lower New Red or "Permian" age occurs in Westmoreland, but it is of no commercial value. Coals of Jurassic age occur in the North of England, and have long been worked for fuel in North-Eastern Scotland. Coal of Neocomian age is known in the South of England. In other parts of the world coal seams in every respect like those occurring in British Carboniferous rocks have been worked in strata belonging to all geological horizons, ranging from Palæozoic up to those of Late Tertiary age. The coals worked in the Midland counties, in Wales, and the parts of England adjoining, pertain to the Upper Carboniferous rocks; but in the North of England, and in Southern Scotland, commercially important coal seams also occur in rocks of Lower Carboniferous age. The coal seams worked in Ireland are usually regarded as being exclusively of Upper Carboniferous age. Amongst the changes which coal has undergone below ground is the development of two (or more) sets of cross fractures perpendicular to the planes of bedding. These divide the coal seams into nearly rectangular portions at close horizontal intervals. These natural divisional planes or joints are known as the CLEAT. They are important factors in the "winning" or extraction of the coal. Several other factors which affect the profitable working of coal remain to be noticed. One of the most important is the nature of the "roof" or bed overlying the coal seam. It is important, in this respect, that the roof should be rigid enough to stand, without much artificial support, over the parts whence the coal has been mined. Another factor is the amount of inclination from the horizontal position which the strata, including the coal seams, have undergone. The presence or the absence of the planes of dislocation (FAULTS) is always an important consideration. The facilities which the position of the mine afford for both ventilation and drainage are, again, of much importance. Lastly, the liability of coal seams to be CUT OUT (*i.e.* to disappear, or be suddenly terminated) has to be taken into consideration. One cause of this nature is due to old channels of erosion, along which the coal has been locally removed while the rocks were in process of formation. These are called WASH-OUTS. Another is due to the presence of sandbanks or other rising ground, against which the deposition of the carbonaceous matter has locally terminated. These banks are known as HORSES. The remaining factor is connected with the formation of eruptive masses, by which the coal seams and their accompanying strata have been invaded after their formation. These intrusive rocks not only cause a deterioration of the coal seams in their neighbourhood, but they also "cut out" (*i.e.* remove) the strata, including the part of the coal seams invaded, wherever they occur. The intrusive rock generally passes into the condition of WHITE TRAP, or WHITE HORSE, in the neighbourhood of the carbonaceous matter, chiefly as a consequence of the reducing action of this latter upon the iron compounds present in the intrusive mass.—J. J. G.

Coal Dust (*Moulding*). Mixed with foundry sand for moulding, and also used as blacking (*q.v.*), or facing for the mould itself.

Coal Gas. *See* GAS MANUFACTURE.

Coal Tar Distillation. *See* GAS MANUFACTURE: COAL TAR DISTILLATION.

Coal Tar Dyes. *See* DYES AND DYEING.

Coarse Hard (*Eng., etc.*) Applied to emery and emery wheels used for rough work.

Coarse Metal (*Met.*) *See* COPPER.

Coarse Stuff (*Plast.*) Lime and sand mixed with hair for the first coat of plastering.

Coat Armour (*Her.*) (1) A coat or garment, bearing armorial insignia, which was worn over armour. (2) Armorial insignia borne by a gentleman.

Coating (*Paint.*) A preparation of plaster placed on the wall for fresco painting.

Coating Machine (*Paper Manufac.*) A machine used for making "art" paper by coating ordinary paper with mineral matter, such as China clay, etc.

Coat of Arms (*Her.*) As now understood, a complete and distinctive heraldic composition: derived originally from the coat armour (*q.v.*)

Coat of Mail. A piece of armour for covering the upper part of the body, consisting of interlaced rings or overlapping plates of iron or steel, attached to a strong linen or leather jacket. The Greeks and Romans wore coats of mail, termed respectively "thorax," and "lorica." *See* ARMOUR (MAIL).

Cobalt, Co. Atomic weight, 59. A white metal with bluish shade (sp. gr. 8·7), harder than iron: magnetic. melts at 1500°: unchanged in air: slowly dissolved by hydrochloric and sulphuric acids, quickly by nitric acid. It is used in electroplating; articles so plated are described as "superior nickel plate." Obtained by strongly heating the oxalate out of contact with air; or reducing the oxide in hydrogen or by heating it with aluminium powder. *See* GOLDSCHMIDT'S PROCESS. Occurs with nickel, and also combined with arsenic and sulphur. This element has not been found native, but it exists in combination in nature in the minerals SMALTINE, COBALTINE, ERYTHRINE, ASBOLANE, and other rarer ones.

—— (*Dec.*) A useful blue pigment of a greenish hue. It is quite permanent, and works better in water than it does in oil.

Cobalt Bloom (*Min.*) A synonym for ERYTHRINE (*q.v.*)

Cobalt Compounds. COBALT OXIDE, Co_3O_4. An oxide of this formula is prepared on a large scale for making SMALT (*see* below), and for colouring glass and porcelain blue, and for preparing cobalt

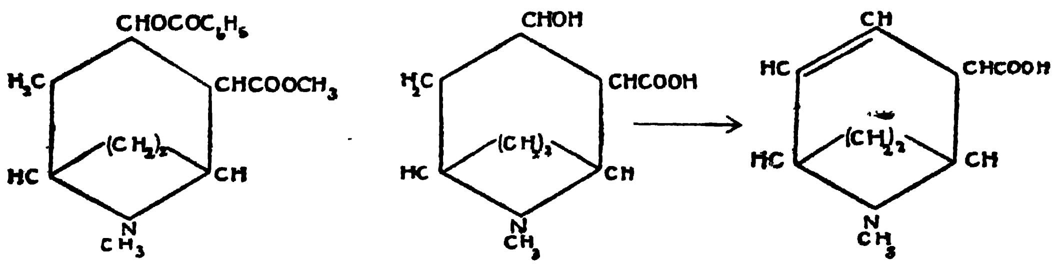
salts. The cobalt ore is roasted, dissolved in acid, and treated with sulphuretted hydrogen to separate arsenic, bismuth, etc.; the solution is then precipitated with sodium carbonate, and the precipitate, treated with oxalic acid, gives a mixture of the insoluble oxalates of nickel and cobalt. On adding ammonia and leaving exposed to air, the cobalt is dissolved and the solution evaporated, and the residue heated in air gives the oxide. SMALT is a double silicate of cobalt and potassium, and is made by heating cobalt oxide with potassium carbonate and finely divided quartz; it is extensively used as a pigment. COBALT CHLORIDE, $CoCl_2$, is blue when anhydrous, and pink when in solution, and is obtained by action of chlorine on the metal or solution of the oxide in hydrochloric acid. COBALT NITRATE, $Co(NO_3)_2$, a red deliquescent crystalline solid obtained by dissolving the oxide in nitric acid. It is used in blowpipe analysis. Solutions of cobalt salts are used as SYMPATHETIC INKS—the pale pink writing is almost invisible, but when warmed before a fire, a trace of moisture is driven off, and the colour becomes blue and is visible.

Cobalt Green (*Dec.*) A pigment composed of zinc and cobalt oxides. It is permanent, but inferior to chrome green (*q.v.*)

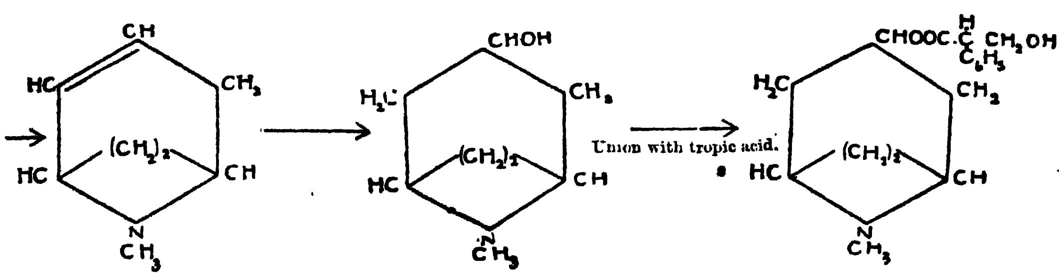
Cobaltine (*Min.*) A sulphide and arsenide of cobalt, CoAsS. It occurs in tin-white crystals of the cubic system. The crystals usually have a faint pink tinge. Also found massive. It is used in the manufacture of smalt. Found in Cornwall, many localities in Sweden and Norway, in Westphalia, etc.

Coca. *Erythroxylon Coca* (order, *Erythroxylaceæ*). The dried leaves are used for the preparation of the alkaloid COCAINE (*q.v.*)

Cocaine. A white crystalline solid; melts at 98°; readily soluble in alcohol, chloroform, and ether; with difficulty in water; lævorotatory. It is a valuable local anæsthetic; very poisonous. Occurs in leaves of *Erythroxylon coca* (South America), and is obtained from the leaves by treatment with caustic soda and petroleum of high boiling point. From solution in petroleum the base is extracted by hydrochloric acid, giving a crude hydrochloride, which is purified. It is also largely produced, synthetically, from ECGONINE, obtained from the mother liquor resulting in the preparation of cocaine. The ecgonine is converted into the methylester by methyl alcohol and hydrochloric acid gas, and this is then treated with benzoyl chloride, yielding cocaine hydrochloride. Cocaine is recognised by the pleasant smell of methyl benzoate, which it gives on warming for some time with alcoholic potash, and by its numbing action when a drop of its solution is placed on the tongue. The following facts are important in relation to the constitution of cocaine: Boiled with water, it gives methyl alcohol, (CH_3OH), and benzoyl ecgonine; boiled with strong acids, it gives methyl alcohol, benzoic acid and ecgonine; cocaine can be reproduced from these (*see* above). It is a tertiary base (*q.v.*) Ecgonine contains a methyl group attached to nitrogen, as it yields methylamine, (CH_3NH_2), when heated with baryta; it is an alcohol, as it loses one molecule of water and forms ANHYDROECGONINE on treating with acetic anhydride and hydrochloric acid gas. Anhydroecgonine is an acid, and it is unsaturated because it adds two atoms of bromine; also, on heating with hydrochloric acid, it loses carbon dioxide and forms tropidine. This last fact establishes the relation to atropine. These facts are all explicable by the following formulæ:



COCAINE. ECGONINE. ANHYDROECGONINE.



TROPIDINE. TROPINE. ATROPINE.

Cocculus Indicus. The one seeded dry fruits of a Malayan climber, *Anamirta cocculus* (order, *Menispermaceæ*). Used in medicine and sometimes as an adulterating agent in porter, etc. The seeds contain an alkaloid, Picrotoxin.

Cochineal. The scale insects allied to the common plant lice (*Aphis*) include the cochineal insect, *Coccus cacti* (order, *Rhynchota*), which infests a Mexican cactus (*see* OPUNTIA). The wingless female insect, dried, is the source of the colouring matter.

The dried bodies are treated with boiling water and a small quantity of alum or cream of tartar, under which treatment they yield a rich crimson pigment used in the manufacture of CARMINE and other LAKES (*q.v.*) *See* DYES AND DYEING.

Cock (*Eng.*) A general term used in engineering, etc., for a tap for the passage of water, or other fluid, or occasionally for some other form of valve opened by hand. The word "tap" (*q.v.*) is applied by engineers to a special tool for cutting internal screw-threads.

Cockatrice. A mythical composite creature partly serpent and partly cock, identical with the basilisk (*q.v.*)

Cocked Bead (*Carp. and Join.*) A half round bead standing above the general surface of the work.

Cockling (*Textiles*). Irregular weaving of warp threads caused by uneven tensioning, thus giving a raw appearance to the cloth.

Cock's Eye (*Plumb.*) *See* BIRD'S EYE.

Cock Up (*Typog.*) Applied to a large type used as the initial letter of the first word of a book or chapter, the foot ranging with that of the other type in the line.

Cocoa. This article of food is prepared by roasting and grinding the seeds of *Theobroma cacao* (order, *Sterculiaceæ*). The fruits contain from fifty to a hundred seeds. Cocoa is nutritious, containing a large amount of fat and starch. Its active principle is THEOBROMINE (*q.v.*) It is often adulterated by the addition of sugar and starch, also by mineral matter, which is added for the purpose of colouring.

Cocoanut. *Cocos nucifera* (order, *Palmæ*). This tropical palm is the source of many important economic products. The fibrous covering of the nuts is used for matting, brushes, and ropes.

Cocoon. *See* SILK.

Cod. The codfish, *Gadus morrhua* (family, *Gadidæ*), and its near allies form an important economic group of food fishes. The oil and skins are also valuable. *See* COD LIVER OIL.

Coda (*Music*). A tail or ending: that portion of a composition or movement which serves as an ending.

Codeine (*Chem.*) $C_{17}H_{18} . CH_3 . NO_3$. An alkaloid. It forms colourless crystals; soluble in water (1 in 80); readily soluble in alcohol and chloroform. It is methyl morphine (*see* MORPHINE), and its physiological action is similar to that of morphine, but less in degree. Occurs with morphine in opium (·3 to 2 per cent.) It can be made from morphine (*q.v.*)

Codetta (*Music*). A short coda.

Cod Liver Oil. A valuable oil obtained from the liver of the common cod. Of the three varieties, pale, pale brown, and brown, the first only is used for medicinal purposes, and is obtained by steaming fresh livers taken from the fish as soon as they are brought ashore. The other two varieties are obtained from livers partly decayed, and are largely used in the manufacture of certain leathers. Sp. gr., 0·922 to 0·930 at 60° F.

Coefficient. A numerical quantity (commonly obtained by experiment) which enters into a formula as a multiplier.

Coefficient of Elasticity. *See* ELASTICITY.

Coefficient of Expansion. (*Heat.*) *See* EXPANSION.

Coefficient of Friction. *See* FRICTION.

Coefficient of Leakage (*Elect. Eng.*) The ratio of the total number of magnetic lines produced by the field magnets of a dynamo, etc., to the total number which passes through the coils of the armature.

Coefficient of Magnetic Induction (*Elect.*) *See* PERMEABILITY.

Coefficient of Magnetisation (*Elect.*) *See* SUSCEPTIBILITY.

Coefficient of Mutual Induction (*Elect.*) If there be two neighbouring circuits, and unit current in one of them cause a certain number of lines of force to pass through the second circuit, then that number of lines is termed the COEFFICIENT OF MUTUAL INDUCTION of the two circuits.

Coefficient of Rigidity. *See* RIGIDITY.

Coefficient of Self Induction (*Elect.*) The total number of lines of force that are caused to pass through a circuit by a unit current flowing in it.

Coefficient of Transformation (*Elect. Eng.*) The ratio of the E.M.F. in the secondary coil of a transformer to the E.M.F. in the primary coil. *See also* TRANSFORMER.

Cœlom (*Zoology*). A term applied to the body cavity of an animal. The cœlom is bathed in a watery fluid (the serous fluid).

Coercive Force (*Elect. Eng.*) The amount of magnetising force that must be applied to an electromagnet in the reverse direction to the original force which was used to magnetise it, in order to reduce the remaining magnetism to zero. The better the quality of the iron the less the remaining magnetism; hence the less the coercive force necessary. *See also* HYSTERESIS.

Cœrulein, Cerulein. *See* DYES AND DYEING.

Cœruleum (*Paint.*) An artist's pigment of a greenish blue hue. It is made from oxides of tin and cobalt; is perfectly fast to light (*i.e.* is not affected by light). It may be imitated on the palette by mixing ultramarine, viridian (*q.v.*), and white.

Cœur (*Her.*) Sometimes used to denote the centre of a shield; otherwise called the centre or fesse point.

Coffee. The so-called COFFEE BEANS are the horny seeds of a cherry-like fruit, *Coffea arabica* (order, *Rubiaceæ*). Coffee has a stimulating effect on the nervous system, its active principle being CAFFEINE (*q.v.*) Coffee is frequently adulterated, more especially when sold roasted and ground. The adulteration can be detected by microscopic examination. The addition of chicory is perfectly legitimate, providing that disclosure is made of the mixture at the time of purchase.

Coffer (*Architect.*) A sunk panel in a dome, vault, or soffit (*q.v.*)

Coffer Dam (*Civil Eng.*) A water-tight enclosure constructed in a river, lake, etc., reaching from the bottom of the water to the surface. It is emptied of water by pumps to enable engineering or building operations to be carried on in the bed of the river.

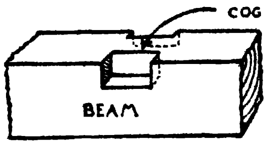
Coffered Ceiling (*Plast.*) A ceiling moulded in the form of panelling.

Coffering (*Mining*). Lining a shaft with masonry, the stones being shaped in plan like the voussoirs of an arch, and built up into successive circular courses.

Cog (*Build.*) *See* COGGED JOINT.

—— (*Eng.*) The tooth of a gear wheel; more especially a wooden tooth, formerly much used in MORTICE WHEELS (*q.v.*)

Cogged Joint (*Carp. and Join.*) A joint having a projection, termed a COG, in the centre.



COGGED JOINT.

Cogging (*Eng.*) Fitting the teeth of a mortice wheel.

—— (*Met.*) The conversion of steel ingots into blooms in a cogging mill or rolls.

Cognisance (*Her.*) A badge or device adopted as a distinctive mark, not placed upon a shield, or used as a crest; *e.g.* the ostrich feathers of the Prince of Wales.

Cognoscente (*Art*). A connoisseur.

Coherer (*Elect.*) A form of detector for electric waves. *See* WIRELESS TELEGRAPHY.

Cohesion (*Phys.*) The property of holding together possessed by the particles of a solid or (to a less extent) by a liquid.

Coif (*Cost.*) (1) In early use, a close fitting cap or hood tied under the chin and worn out of doors by both sexes. The head covering of women in foreign countries. (2) A cap worn by serjeants-at-law, afterwards represented by a white border or a small patch of black silk on the top of the wig.

Coil (*Eng., etc.*) (1) A number of turns of wire, rope, etc. (2) Turns of piping used for the purpose of radiating heat. (3) In electricity, a number of turns of wire (usually insulated) wound either on a solid core or on a hollow reel; especially an INDUCTION COIL (*q.v.*) *See also* SOLENOID.

—— (*Motor Car*). An INDUCTION COIL (*q.v.*) which gives a hot spark for igniting the explosive charge in the cylinder. The coil is usually worked by an accumulator of two cells, giving about 4 volts.

Coiler (*Cotton Spinning*). A mechanism attached to the carding and drawing machines for coiling the strands or SLIVERS (*q.v.*) in a special tube-shaped can.

Coins. Flat pieces of metal of various thickness and value, generally bearing the image of the sovereign, or some symbolical figure or figures. Ancient coins, especially those of Greece, are of great importance as objects of art, and they also serve to illustrate the history of art. *See* BLANKS.

Cointise (*Cost.*) A fanciful dress. The pendant scarf on ladies' headdresses; sometimes worn by knights on their helmets in jousts as a "favour."

Coke. The product of the destructive distillation of coal (*cf.* CHARCOAL). GAS COKE is the result of heating coal in retorts in gasmaking. OVEN COKE, or HARD COKE, used for smelting and various metallurgical operations, is manufactured in special ovens or furnaces. The essential requirement in coke used for these latter purposes is freedom from sulphur, arsenic, and phosphorus, but up to the present time it has not been found possible to eliminate all sulphur. Coke is also used to a large extent as a medium for the bacterial treatment of sewage, for which purpose it seems to answer well.

Coke Bed (*Met., Foundry, etc.*) (1) A layer of coke placed at the bottom of a cupola. (2) A layer placed below large moulds, forming a porous mass which affords a means of escape for the gases produced during the pouring of the metal into the mould.

Coke Breeze. Crushed coke: used as fuel, as a filling for hollow floors in building, and for various other purposes.

Coke Mill (*Foundry*). A mill for grinding coke into powder for use as blacking (*q.v.*) in a foundry.

Coke Plate (*Met.*) Thin sheet made from ordinary puddled iron. It was originally so called to distinguish it from iron refined by means of charcoal.

Colas' Process (*Photo.*) A printing process in which the paper is coated with ferric salts, which are converted into ferrous salts under the action of light. The print is developed by gallic acid, which blackens the portions unacted on by the light. This process gives a negative from a negative, and a positive from a positive; hence, in copying a tracing, it gives black lines on a white ground.

Colcothar (*Chem.*) The commercial name for a red pulverulent ferric oxide, (Fe_2O_3). Also known as ROUGE.

Cold Air. *See* REFRIGERATORS.

Cold Bend (*Eng.*) Testing iron bar and plate by bending. The angle at which cracking begins is a test of the quality of the iron; hence this is often laid down in the specifications of contracts for ironwork.

Cold Blast (*Met.*) The old method of working blast furnaces, etc., by a blast of cold air; it was less economical, but produced a better quality of iron than the modern Hot Blast. It is now almost obsolete.

Cold Chisel (*Eng.*) A chisel of strong hard steel, made of one piece of metal, and tempered so as to be able to cut iron when struck with a chipping hammer, but not made so hard as to be liable to fracture under the blows. This requires the steel to be tempered to a colour varying from brownish yellow to light purple, *i.e.* from 500° to 530° F. *See* TEMPERING. Also used for cutting brick, stone, etc.

Cold Iron Saw (*Eng.*) A small thick circular saw with the cutting edge of the teeth parallel to the axis of the saw; run at a slow speed.

Cold, Production of (*Physics*). *See* REFRIGERATORS.

Cold Riveting (*Eng.*) Closing up rivets without previously heating them. This method of riveting is always used with copper rivets, but is not used with iron ones, except in the smaller sizes.

Cold Rolling (*Eng.*) The rolling of iron, cold, gives considerable tensile strength, but lowers the toughness; much greater smoothness of surface is obtained than when rolled hot.

Cold Set (*Eng.*) A short chisel fastened to a long rod at right angles to its length, used by smiths for cutting iron bars without heating.

Cold Short (*Eng., Met.*) Iron or steel which is brittle "in the cold" (*i.e.* below a dull red). This defect is chiefly due to the presence of phosphorus, arsenic, or silicon. *Cf.* RED SHORT.

Cold Test (*Eng.*) *See* COLD BEND.

Cold Water Test (*Eng.*) Hydraulic testing of a boiler with cold water, as distinguished from tests with hot water or steam. The water is forced into the boiler under pressure, and the seams, etc., are examined for leakage, yielding, etc.

Collar (*Eng.*) A ring on a shaft either turned up out of the solid metal or added as a separate piece, usually to prevent end play or longitudinal motion of the shaft.

—— (*Orders*). An ornament in the form of a chain worn round the neck, especially as the insignia of an order of knighthood. A collar is part of the investiture, and is worn by the knights of the following English Orders: Order of the Bath, St. Michael and St. George, and the Star of India.

Collared (*Her.*) Wearing a collar.

Collaring (*Met.*) The adhesion of a bar to the rollers during the operation of rolling.

Collar Roof (*Carp.*) A roof having a horizontal beam (collar) fixed to the rafters one-half or one-third of the way up, to prevent them spreading or sagging. *See also* ROOFS.

Collate (*Typog. and Bind.*) To examine or to place in order, by their signatures, the sheets of a book: a SIGNATURE being a letter or figure in the white line at the foot of the first page of each sheet or section of a book.

Colla Voce (*Music*). With the voice. Used in accompaniments.

Collecting Rings (*Elect. Eng.*) The insulated rings on the shaft of an alternate current machine by which the current is led away from, or into, the machine from the external circuit. They are used in most cases when a current has to be led into, or out of, any circuit (*e.g.* a ROTOR, *q.v.*) carried on a revolving shaft. Each end of the wire forming the circuit is attached to one ring; a brush or conductor of suitable form, supported by an insulated holder, presses on each of the rings as they revolve; the external circuit is connected to these conductors, and through them to the revolving part of the machine.

Collidines (*Chem.*) The TRIMETHYL PYRIDINES. *See* PYRIDINE.

Collodion. A solution of PYROXYLINE (*q.v.*) in alcohol and ether. It is used in making artificial silk, plates for photography, and for covering small wounds to exclude air, etc. Collodion-covered or "wet" plates are now superseded in ordinary cases by gelatine films, but are still used in certain special kinds of photographic work.

Colloid (*Phys.*) Substances of the nature of jelly (*e.g.* glue, gelatine, albumen). They are non-crystalline, can only diffuse very slowly through a membrane, and probably possess very large molecules.

Colloidal (*Phys*) Having the properties of a COLLOID (*q.v.*) Many bodies, *e.g.* silica, can exist both in a crystalline and in a colloidal or amorphous form.

Cologne Earth (*Paint.*) A deep brown pigment prepared from lignite or partially fossilised wood. It is transparent and durable.

Cologne Yellow (*Paint.*) A pigment produced by mixing chromate and sulphate of lead with sulphate of lime.

Colon (*Typog.*) A punctuation mark, thus :

Colonnade (*Architect.*) A range of columns either attached to a wall or at some distance from it. *See* PORTICO *and* PERISTYLIUM.

Colophon (*Typog.*) A device or emblem placed at the end of a book or manuscript. Formerly (*i.e.* in early printed books) it conveyed the information now given on the title page.

Colossus (*Sculp., etc.*) A statue or figure many times larger than life size. Amongst remarkable examples are the statue of Apollo at Rhodes, the Egyptian Sphinx, the figure of Osiris, and the modern statue of *Liberty*, from the design by Bartholdi, erected at the entrance to New York harbour.

Colour (*Botany*). Any part of a plant which is not green is said to be "coloured." Hence, in botany, a white flower is said to have colour.

—— (*Build.*) In the builder's use of the word, to "colour" is to paint either in oil or distemper: the term is applied chiefly to work on walls or ceilings.

—— (*Phys.*) The sensation of colour is due to the effect (or sensation) produced upon the retina of the eye by light of some particular wave length (*q.v.*), or by a mixture of light of several wave lengths. The sensation is only produced by light whose wave length varies from about ·00003938 cm. to ·00007594 cm. Waves lying outside these limits are not detected by the eye, though they may be detected by other means, such as their thermal or their chemical effects. A given colour can only be fully described by means of three properties which it possesses: (1) HUE or Tint, (2) LUMINOSITY, and (3) PURITY. The first of these depends on its frequency, and is analogous to the Pitch (*q.v.*) of a sound; the second depends on the amplitude of the vibrations, and is analogous to the Loudness of a sound; the third depends upon its freedom from admixture with white light, and is to some extent analogous to the Timbre or Quality of a sound. The colour of an object is due to the light which it sends to the eye; accordingly, in the case of a body which is not self-luminous, the apparent colour will depend upon the nature of the light by which the body is illuminated; it is therefore not an inherent property, and will vary when the object is viewed by different kinds of light. In ordinary language, the colour of a body means that particular colour or hue which it sends to the eye when it is illuminated by sunlight, either direct or diffused. *See also* COLOURS (*Pigments*), SPECTRUM, SPECTRUM ANALYSIS, *etc.*

Colour Base (*Chem.*) The name given to a basic substance which is itself colourless, but whose salts are dyes. Thus triamidotriphenyl carbinol,

$$\begin{matrix} H_2NC_6H_4 \\ H_2NC_6H_4 \end{matrix} > \underset{\displaystyle OH}{\overset{}{C}} - C_6H_4NH_2$$

is colourless, but its salts are dyes of an intense red colour.

Colour Blindness (*Light*). The inability of a person to distinguish one colour from another. It corresponds to the lack of a "musical ear," which is the inability to distinguish tones or sounds of different frequencies. Both these defects are usually partial only; a colour-blind person is as a rule able to distinguish certain colours, but not all.

Coloured Screens (*Photo.*) *See* PHOTOGRAPHY IN COLOURS *and* ISOCHROMATIC PHOTOGRAPHY.

Colouring (*Paint.*) A term used with reference to the manner or style in which the colours have been handled in a painting, but more especially with reference to the general effect produced by the colours employed. *See* COLOURIST.

Colourist. A painter who excels or who aims at excellence in colouring, *i.e.* brilliance and harmony. The painters of the Venetian School, notably Titian and Veronese, excelled as colourists, as also did

Velasquez, Rubens, Rembrandt, Eugène Delacroix, Constable, and, in recent times, some members of the pre-Raphaelite School.

Colourless (*Botany*). A green part of a plant is said to be colourless. *See* COLOUR (*Botany*).

Colour, Local. Tone or colour appropriate to a particular object in a picture: realistic representation of scenes, with proper accessories.

Colour Photography. *See* PHOTOGRAPHY IN COLOURS.

Colour Printing. *See* PRINTING; CHROMOLITHOGRAPHY, *under the head* LITHOGRAPHY; *and* CHROMOXYLOGRAPHY, *under the head* ENGRAVING (CHROMOXYLOGRAPHY).

Colours (*Pigments, Dec., etc.*) The word colour is commonly applied to pigments used for imparting colour to various objects. The study of this subject is a very complex one, and is surrounded by many difficulties, not the least of which is the fact that the colour sense varies largely in different individuals, while about one person in eighteen is partially colour blind, *i.e.* cannot distinguish between certain different colours. There is no settled nomenclature for colours, and this adds to the difficulty. A consideration of colour may conveniently be divided into two distinct parts, one relating to colour in the scientific sense (*see* COLOUR), and the other the colour of the artist, dyer, and house painter. Colour has no concrete existence, but must be considered merely as a sensation. A plant, for example, which is of a bright green colour when viewed in the daylight. loses that colour wholly when taken into a dark room. All objects are seen by rays of light reflected from such objects on the retina of the eye by means of a set of lenses. Certain nerves susceptible to colour are excited at the same time, so that a perfect picture as to form, colour, and shading is produced. Ordinary sunlight is not simple, but complex, consisting of all the colours in combination. This was first demonstrated by Newton in his classical experiment. He pierced a hole through the closed shutter of a window upon which the sun was shining, so as to admit only a beam of sunlight. Having placed a glass prism in the path of this beam, he obtained a spectrum (*q.v.*), having upon it all of the colours of the rainbow, each merging into the other immediately adjacent to it. He thus established the fact that white light is composed of a number of beams or rays of coloured light. The splitting up or refraction of light in order to produce all the colours in a spectrum may be done in various ways on a scientific basis, such as by a glass prism, a diffraction grating (*q.v.*), etc. In each case the spectrum is essentially the same, including, first, red, then red-orange, followed by orange, orange-yellow, yellow, green-yellow, yellow-green, green, blue-green, cyan blue, blue, blue-violet, and violet. We have thus a series of colours, one merging into the other, and giving a very great variety of hues. Indeed, it is probable that a sensitive eye can distinguish between some two million different colours. No doubt the power to distinguish the small differences in hue is a matter of cultivation. Savages are probably able to distinguish only the most striking differences, such as the bright reds, greens, and yellows. It is probable, too, that in the early history of mankind the eye was uncultivated, and that it is among cultured people that the greatest sensitiveness in distinguishing colours is found Insects are without doubt susceptible to colour and it is here that nature causes colour to play a useful part; *e.g.* the hue of the petals of a flower is such as to attract (in conjunction with the perfume) the fertilising insects. If any colour in a spectrum be separated from the rest (this can be readily accomplished by piercing a screen upon which the spectrum is thrown), and if this single colour is allowed to pass through a second prism, it will be found that it may again be divided up, excepting in the case of red, green, and violet, which remain unchanged, and are therefore termed the three PRIMARY COLOURS. As will presently be explained, these primary colours do not correspond with what were formerly accepted as primaries, *viz.* red, blue, and yellow, the latter being based upon the results obtained from the admixture of pigments. If three magic lanterns are fitted respectively with red, green, and violet glasses of exactly the right hue, and the beams of these different coloured lights are allowed to fall upon the same spot on a screen, white will be the result. There is some difference of opinion as to the exact hue of the three primary colours named, but the consensus of opinion is that the red is similar to that produced by the admixture of carmine and vermilion (the well known post office red, for example), while the green is emerald green (*q.v.*), and the violet somewhat bluish in hue. The most convenient method of considering the differences in effect produced by coloured lights or coloured pigments or dyes is to consider that such pigments or dyes are not the colours themselves, but the bodies which produce the sensation of colour. The accepted theory is that when white light falls upon a green plant, for example, all the rays are absorbed excepting the green rays, which are reflected to the eye. When admixtures of coloured light are made, either by means of magic lanterns or by revolving discs, the result is very different from the admixture of the same coloured pigments. Thus red and green light when mixed give yellow, but red and green pigments yield a brown. Blue and yellow lights give a greyish white, while, as is well known, blue and yellow pigments give a green. In dyes the difference is even more striking. David Paterson gives a number of instances—*e.g.* red and yellow-green in dyes give a terra-cotta shade when mixed, but in the case of light a very pale pink; a deep shade of red and green in dyes yields black, and in coloured lights a grey. Blue and red dyes produce a deep red or maroon, but in light a violet purple. The same difference is apparent in house painters' and artists' pigments. For example, a mixture of yellow and black gives a good neutral green. It should therefore be considered that the admixture of pigments changes their qualities by the absorption of light, or at least the reflected rays are, in the aggregate, changed, and hence the appearance is different. In practical work the mixture of coloured light is generally discarded, although a knowledge of the subject is essential to its investigation. When different colours are arranged side by side in minute quantities, and are viewed from a distance, the rays of light reflected from each combine, giving practically the same result as would be obtained, not from an admixture of the different coloured pigments employed, but of the lights they represent. Colour printers frequently combine colours in the same way, as, for instance, in producing a series of red tints by "ruling up," or introducing very fine white lines between the coloured ones. It is stated that experiments conducted recently with a view to ascertaining which colours may be most advantageously employed for painting guns so as to render them least con-

spicuous to the enemy, resulted in the discovery that if the primary colours were used in dots and in the proper proportion they would, when viewed at a distance, be almost invisible, the explanation being that the light of the three colours reflected over a long distance combined so as to form a white light, and consequently the gun was rendered practically invisible. It has already been stated that the three primary colours or sensations are red, green, and violet; the three primary pigments are usually red, blue, and yellow, and it will be observed that the term "red" is used in both cases. It need hardly be pointed out that "red" does not refer in each case to the same colour, which is another illustration of the inconvenience which arises from a want of nomenclature of colours. If the position of the six colours, *viz.* the three primary pigmentary colours and the three primary colours of light or sensations, be taken from a spectrum, it will be found that they do not coincide. The red pigment is of a somewhat violet hue, while the red colour light is a distinct orange hue, and this explains the whole difference. We may thus set out the colours as corresponding with the spectrum: Red (pigment), red (sensation), yellow (pigment), green (sensation), blue (pigment), violet (sensation). The study of complementary colours is one which is of the utmost interest in the solution of problems relating to colour harmony, and is indeed the foundation upon which a study of the subject is founded. Speaking broadly, a complete colour harmony may be said to consist of such a combination of all the colours as, when viewed as a whole, one set of colours tends to neutralise the others. Thus the eye is not unduly excited by a single colour, or excess of a single colour, as it would be when the combination was out of harmony. A room painted in a single colour becomes distressing to the eye, because it unduly excites the nerves of that particular colour, which soon become tired. Setting down the above-mentioned primary colours in regular order, and calling the "red" of the colour sensation "orange," we have the following table:

PRIMARY COLOURS. *Pigments.*		PRIMARY COLOURS. *Sensations.*
Blue is complementary to	.	Orange.
Red is complementary to	.	Green.
Yellow is complementary to	.	Violet.

If the spectrum be so arranged as to form a circle, that is, the red joining the violet, there will be found to be no distinct break between the two, the red merging into the violet, as might be expected. A colour circle of this kind can be used by the decorator to ascertain at a glance the colour complementary to any other colour. For example, a bright crimson red immediately faces, or is opposite to, emerald green, and this emerald green consists of a mixture of blue and yellow; hence we have the three colours which form in theory white, or a combination of all the colours in one. COLOUR MIXING: Although the general understanding is that all colours may be made from an admixture of red, blue, and yellow pigments, yet in practice it is found convenient to use a much more extended palette. Speaking generally, it may be said that the more expert a mixer is the fewer number of palettes he will require. The palettes of well known artists differ exceedingly, and each shows some individuality. Professor Church gives the following palettes: Sir Joshua Reynolds, (1) Flake white, yellow ochre, lake, ultramarine, black. (2) Flake white, Naples yellow, yellow ochre, carmine, vermilion, ultramarine, and black. Sir John Gilbert, R.A. (fifteen pigments), Chinese white, yellow ochre, raw sienna, vermilion, light red, Venetian red, Indian lake, cobalt, artificial ultramarine, indigo, Prussian blue, Antwerp blue, burnt sienna, Vandyke brown, ivory black. Church gives the following selection as a general working set for oils of twelve pigments: Flake white, cadmium, yellow aureolin, yellow ochre, vermilion, madder, carmine, light red, viridian, artificial ultramarine, raw umber, cappagh brown, and ivory black. By way of a contrast, the palette of the Hon. John Collier may be given. This is as follows: Flake white, raw sienna, yellow ochre, orange vermilion, Chinese vermilion, rose madder, burnt sienna, emerald oxide of chromium, cobalt blue, ivory black, and raw umber. Many artists' primary consideration is obviously the permanent character of the pigments employed and the avoidance of those which will destroy one another. With house painters the cost is of much greater importance. The earth colours, such as siennas, ochres, and umbers, and the cheaper colours, such as Prussian blue, ultramarine (artificial), and the chromes are used freely with small quantities of vermilion, black, and the finer colours. The house painter obtains a series of reds by using either vermilion or its equivalent, known as fast red, mixed with either white ochre or Venetian red. His blues are mostly produced from ultramarine and Prussian blue, the former being discarded when the base is white lead, owing to the fact that it is adversely acted upon because of the sulphur it contains. In yellows he has a variety of different shades of chrome yellows, ranging from a very light "canary" to a deep orange, which is almost red. Cadmium yellow (*q.v.*), although expensive, is most useful, while zinc yellows are also used to some extent, owing to the fact that they are not affected by impure air, as the chromes are. Drabs, fawns, and light browns generally are easily obtained from a mixture of French ochre or Italian sienna, mixed with white lead, a little Indian red, Venetian red or black being introduced where necessary to give variety. The brilliancy of a colour in house painting is frequently added to by the process known as GLAZING (*q.v.*), or giving a coat of transparent colour over a suitable ground, such, for instance, as sienna and lake on a less vivid but solid colour. *See also* HUE, TINT, SHADE. A. S. J.

Colours, Blended (*Paint.*) The harmonious effect produced by the gradual blending of one tone or colour with another.

——, Complementary. Two colours are complementary to each other if, when mixed, they make white. It is to be noted that this is true of COLOURS, but not of pigments. *See* COLOURS (*Pigments*).

——, Heraldic. *See* HERALDRY.

Colour, Shot (*Textiles*). A material woven in various colours in such a manner that when observed at different angles the colours appear to change.

Colours of Thin Films (*Light*). Brilliant colours are given by any sufficiently thin transparent film, *e.g.* a film of oil floating on water. The colours are due to interference (*q.v.*) between light waves reflected from the two surfaces of the film. The colours vanish, however, if the thickness of the film become small compared to the wave length of the light falling upon it, and the film then appears black.

Colours, Primary (*Light*). A primary colour is one which cannot be produced by the mixture of any

two (or more) different colours. The colours usually accepted as the primaries are Red, Green, and Blue; but there are reasons for considering that Violet is primary, rather than Blue. The question of primary colours was first studied by artists, who decided that they were Red, Yellow, and Blue, as it was impossible to produce *pigments* of either of these hues by the admixture of any two other pigments. But a pigment owes its hue to a combination of the processes of reflection and absorption, and experiment has shown that green, and not yellow, is a true primary. *See also* COLOURS (*Pigments*).

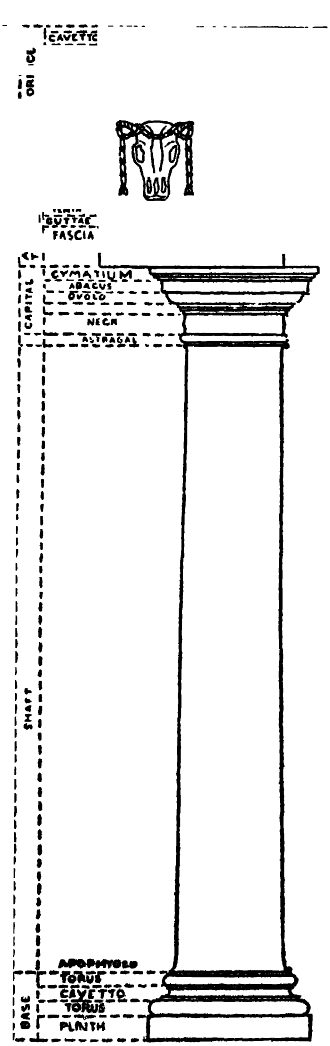
Colours, Prismatic. *See* SPECTRUM *and* SPECTRUM ANALYSIS, *etc.*

——, Secondary (*Paint.*) Colours resulting from a mixture of two of the so-called primary colours (*q.v.*), or, more correctly, pigments of these colours. They are Orange, obtained from red and yellow; Green, from blue and yellow; Purple, from red and blue.

——, Tertiary (*Paint.*) Various grey colours produced by the mixture of two secondary colours (*q.v.*), such as red-grey, blue-grey, yellow-grey; or violet-grey, green-grey, orange-grey, according as the primaries or secondaries are in excess.

Columbier. Drawing paper about $34\frac{1}{2} \times 23$ in. in size.

Column (*Architect.*) A vertical support of considerably greater length than thickness. In Greek, Roman, and Renaissance work the column is one of the chief divisions of the order, and is again subdivided into three parts, the base, shaft, and capital, except in the case of the Greek Doric order, in which the column has no base. *See* ARCHITECTURE, ORDERS OF: DORIC, IONIC, CORINTHIAN, TUSCAN, COMPOSITE, ENGAGED COLUMN, *and* CABLED COLUMN.



COLUMN: ROMAN DORIC.

—— (*Eng., etc.*) A vertical support subjected to compression. An overloaded column almost invariably fails by bending, not by crushing, of the material, and therefore the column should be designed to resist flexure; *i.e.* the MOMENT OF INERTIA (*q.v.*) of its cross section should be as large as it can conveniently be made. This is best effected by making the column hollow. A given weight of material then forms a much stiffer support than it does if made into a solid column.

Columnar Structure (*Geol.*) A rock structure which takes the form of polygonal columns, often hexagonal in outline. It is clearly traceable to the effect of cooling, upon a rock which has been at a high temperature; and the longer axes of the prisms or columns usually extend at right angles to the surfaces of cooling. It is often developed to a remarkable extent in basalts; but it is by no means of rare occurrence also in coal seams, in clays, or in sandstones, which have been exposed to heat.

Colza Oil *or* **Rape Oil.** Colza oil is obtained from the seed of the Rape plant, *Brassica napus* (order, *Cruciferæ*), by pressure. The residue forms OIL CAKE, used for feeding cattle. The oil is largely used for lubricating and illuminating purposes, and in lesser quantities for making soft soaps and blacking. When employed for lubricants it is usually thickened by blowing. *See* BLOWN OIL. It possesses a characteristic taste and smell, and when refined is pale yellow; sp. gr. 0·912 to 0·920 at 60° F.

Comb (*Bind., Dec.*) An instrument with wire teeth used in MARBLING (*q.v.*); it is also used in decorators' work. *See* COMBING *and* GRAINING.

Comb Bar (*Lace Manufac.*) A very accurately shaped and finished bar of iron, in some cases faced with brass, upon which the "comb leads" are screwed side by side, thus forming a continuous series the width of the machine.

Combed Yarns (*Cotton Spinning*). A good quality of spun yarn, usually Egyptian or Sea Island Cotton, which has undergone the combing process in addition to CARDING (*q.v.*)

Comber Board (*Cotton Weaving*). A length of wood or a number of wood slips placed in a frame. They contain finely bored holes, through which are passed the harness thread or coupling of a Jacquard. Used for keeping threads and couplings in position and determining their set or closeness. Also termed COMPASS BOARD.

—— (*Silk Manufac.*) Slips of wood framed together to width of figured harness, and perforated with holes disposed in lines through which the couplings or lashes carrying the mails and lingoes in mounture are led. From this point they are connected by necking cords with the Jacquard machine.

Combination (*Lace Manufac.*) A term used in the manufacture of lace curtains, signifying that a more complex movement of the threads has been necessary than in the case of ordinary curtains.

Combination Tones (*Sound*). Tones or notes sometimes heard when two notes which produce beats are sounded together. Their frequencies are either the sum or the difference of the frequencies of the two separate tones which are being sounded. In the first case the tone is termed a SUMMATION TONE, in the second a DIFFERENCE TONE. In certain circumstances, additional combination tones, termed BEAT TONES, may also be detected.

Combined Carbon (*Met.*) Carbon chemically combined with iron occurs in cast iron and steel, some form of binary compound—a CARBIDE (*q.v.*) —probably being formed. *See also* IRON.

Combing (*Cotton Spinning*). Combing is a very important and necessary process where fine yarns of good quality are required to be spun. The object is to eliminate all fibres under a certain length, so that those remaining may be uniform and placed parallel, thus producing a regular and clean sliver. The most successful is the Heilmann comber. Others in use are Hübner's, Imb's, Staub & Montford's, Delette's, Gegauff, Nasmith's.

—— (*Dec.*) Graining done with a comb, a flat flexible metal plate divided up into parallel tongues. *See also* GRAINING.

—— (*Woollen Manufac.*) The process of straightening fibres of materials, *e.g.* wool, mohair, alpaca, and cotton, in which the short and nappy fibre is removed. The straightened material forms the TOP, and the extracted fibres the NOIL.

Combining Weights *or* **Combining Proportions** (*Chem.*) The proportions in which elements or compounds enter into reaction with each other. These proportions are either the same as the atomic or molecular weights or some simple multiple or submultiple of these.

Combs (*Lace Manufac.*) In a lace machine, thin strips of iron, brass, or steel, segmental in shape, forming grooves on which the carriages work.

Combustion (*Chem.*) The chemical union of substances when this "union" is accompanied by the evolution of light and heat.

Combustion Chamber (*Eng.*) (1) The part of a furnace or boiler flue where the major part of the gaseous products are burnt. (2) The part of a gas (or oil) engine in which the explosion of the charge occurs.

Combustion, Spontaneous. *See* SPONTANEOUS COMBUSTION.

Come Prima (*Music*). As at the beginning.

Comets (*Astron.*) Bodies consisting of or analogous to swarms of METEORITES (*q.v.*) which describe a parabolic or elliptic orbit round the sun. Comets moving in space outside the solar system have no luminosity; but this is developed as they approach the sun, and the mass gradually becomes differentiated into a dense bright part, the NUCLEUS, and a streaming TAIL pointing away from the sun. The spectrum of a comet shows that its luminosity is not entirely due to reflected light; the increasing luminosity as it approaches the sun is due to increased activity, resulting in increased temperature, and is accompanied by modifications in its spectrum.

—— (*Her.*) A star of six points with a fiery tail.

Comma (*Sound*). The difference between a MAJOR TONE (the interval $\frac{9}{8}$) and a MINOR TONE (the interval $\frac{10}{9}$); that is, the interval $\frac{81}{80}$.

—— (*Typog.*) A punctuation mark: thus ,

Commercial Uses of the Microscope. *See* MICROSCOPE, COMMERCIAL USES OF.

Common Colours (*Dec.*) In painters' work, common colours are defined as white, black, red, umber, ochre, etc. No "art shades" or colours other than simple ones in ordinary use are included.

Common Joists (*Carp., Build.*) The ordinary JOISTS (*q.v.*) to which the floor boards are nailed; they rest on the WALL PLATES (*q.v.*) or on other joists termed BINDERS. *See also* FLOORS.

Common Salt (*Chem.*) *See* SODIUM CHLORIDE, *under* SODIUM COMPOUNDS.

Common Time (*Music*). That rhythm which has the accents occurring alternately. Originally marked by a semicircle thus, C, to distinguish it from TRIPLE TIME (*q.v.*) It is now printed thus, $\mathbf{C}$.

Communicable Disease. *See* INFECTIOUS DISEASE.

Commutator (*Elect. Eng.*) The device by which an alternating current produced in the rotating coils of the armature of a dynamo is converted into a unidirectional or continuous current in the rest of the circuit. In the simplest possible case, where the armature carries one coil only, the commutator consists of two segments, forming the two parts of a SPLIT RING. The segments are insulated from direct contact with each other, but each is connected to an end of the coil. In actual practice the armature always contains a number of coils, and these are connected to the corresponding segments or BARS of the commutator. The bars are strips of copper or phosphor bronze, arranged round the surface of a drum or cylinder fixed on the shaft of the armature, and insulated by means of mica, vulcanised fibre, etc. *See also* DYNAMO.

Comodo (*Music*). Conveniently, moderately.

Companionship (*Typog.*) A number of compositors working under the management of a CLICKER (*q.v.*)

Comparator (*Phys.*) An instrument for comparing a given scale of lengths with a Standard Scale. It consists essentially of two READING MICROSCOPES (*q.v.*) fixed accurately at a given distance apart, this distance being kept absolutely constant during the observations.

Compass. An instrument used for describing circles and for taking measurements. *See* BEAM, BOW, HAIR, TRIANGULAR, PROPORTIONAL COMPASSES; *see also* CALLIPERS *and* ELLIPTIC TRAMMEL.

—— (*Music*). The range of sounds that can be produced by a voice or instrument; it is measured by the interval between the highest and lowest notes.

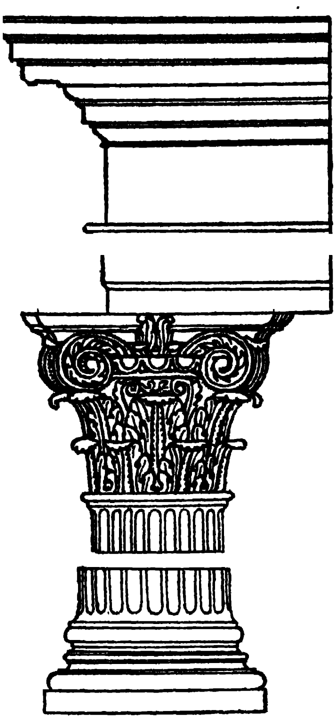
Compass Board (*Cotton Weaving*). *See* COMBER BOARD.

Compass, Magnetic (*Elect.*) A magnetic needle (*q.v.*) mounted on a fine pointed pivot in a suitable case: a card, graduated into degrees and having the cardinal points (*q.v.*) marked upon it, is fixed to the case underneath the needle. In the FLOATING CARD COMPASS the card is attached to the needle, so that the diameter joining the points marked N. and S. makes an angle with the needle equal to the magnetic declination (*q.v.*) The card and needle are so mounted as to turn together; then, when the needle comes to rest in the magnetic meridian, the abovementioned diameter will lie in the true geographical meridian. The floating card compass is very convenient for use in an area over which the magnetic declination (*q.v.*) is constant.

Compass Saw (*Carp.*) A narrow straight saw for cutting curves.

Compensated Pendulum (*Phys.*) A pendulum provided with some means of maintaining a constant length during changes of temperature, *i.e.* of counteracting the expansion or contraction of the rod. *See* PENDULUMS (HARRISON'S AND GRAHAM'S).

Compensating Collars (*Eng.*) Rings or collars, on a shaft, that can be adjusted so as to take up "wear." They are used especially in those machines in which there is a longitudinal thrust on the shaft, *e.g.* in a drilling machine.



COMPOSITE ORDER (*Architect.*)

Compensating Gear (*Motor Cars*). DIFFERENTIAL GEAR (*q.v.*)

Compensation Balance (*Watches, etc.*) A balance designed to correct the errors in time due to variations in the temperature.

Complement. The difference between an angle and 90° (*i.e.* a right angle) is termed the Complement of the angle.

Complementary Bows (*Meteorol.*) *See* RAINBOWS.

Complementary Colours. *See* COLOURS, COMPLEMENTARY.

Complete Combustion (*Eng., etc.*) A process in which all the carbon and other oxidisable constituents of a fuel are fully oxidised; that is, burnt up or combined with the maximum amount of oxygen.

Compo (*Build.*) Mortar made of cement and sand: the term is, of course, a builder's abbreviation of COMPOSITION.

Component. (1) A single separate part of a machine or structure. (2) In theoretical mechanics the components of a force are the various separate forces which, acting together, would produce the same result as the given force. A force may be split up into any number of components.

Components (*Cycle*). Parts of a cycle such as the brackets, hubs, cranks, and pedals which are sold machined and finished ready for building up the frame and wheels; they are the parts which a small maker cannot profitably make for himself, owing to the lack of elaborate machinery.

Compony *or* **Gobony** (*Her.*) A border or other ordinary divided into alternate tinctures.

Compo Pipe. Small gaspiping, composed of an alloy instead of pure lead.

Compose (*Typog.*) To set up type for printing.

Composing Frame (*Typog.*) A frame standing about breast high, on top of which the type cases in use rest at different angles. The lower part of the frame contains racks for holding cases not in use.

Composing Machine (*Typog.*) A mechanical contrivance for setting up type. The LINOTYPE (*q.v.*) is one of the best known examples.

Composing Rule (*Typog.*) A brass RULE (*q.v.*) laid in a composing stick, and against which the type is set: it facilitates the process and is shifted as each line of type is completed. Known also as a SETTING RULE.

Composing Stick (*Typog.*) An implement in which the compositor sets type. It has an adjustable part which allows the line of type to be set to the length required.

Composite Order (*Architect.*) A Roman modification of the Corinthian order, consisting of a combination of the Ionic and Corinthian capitals, the other features of the Corinthian order being little changed. *See* ARCHITECTURE, ORDERS OF: CORINTHIAN *and* IONIC.

Composite Truss (*Build.*) A TRUSS (*q.v.*) composed of wood and iron or wood and steel. *See also* ROOFS.

Composition (*Fine Arts*). The combination of the several parts of a subject in such manner that each part is in harmony with and subordinate to the whole, the subject being so presented as to be both easily understood and agreeable.

Composition of Forces (*Mechanics*). The process of finding what single force (or RESULTANT) would, if acting alone, produce the same effect as a given number of separate forces (the COMPONENTS). *See also* GRAPHIC STATICS.

Composition Pedals (*Music*). A mechanical contrivance for changing the STOPS (*q.v.*) on organs.

Compositor (*Typog.*) One who sets or composes type.

Compound (*Chem.*) A substance composed of two or more elements, chemically united; *i.e.* so united as to produce a new substance, whose chemical and physical properties differ from those of its constituents.

Compound Engine (*Eng.*) A steam engine in which steam is partly expanded in one cylinder and then allowed to enter a second (or low pressure cylinder), in which it is further expanded. A third or even fourth cylinder may be added, the engine being then termed a TRIPLE or QUADRUPLE EXPANSION ENGINE.

Compound Harness (*Cotton Weaving*). A method of mounting or tying up HARNESSES (*q.v.*) on a Jacquard, by which economy is anticipated either in labour, designing of patterns, or cost of pattern cards. There are several forms, the following being the chief: (1) Bannister; (2) Damask; (3) Double cloth or split; (4) Quilting; (5) Tapestry.

Compounding (*Eng.*) The addition of a low pressure cylinder to an engine which previously possessed a high pressure cylinder only. By this means an additional amount of useful work may be obtained which was previously wasted when the steam was allowed to escape at a high pressure.

Compound Levers (*Eng., etc.*) A system or train of levers in which the short arm of one lever acts on the long arm of the next. It is used in large weighing machines and in some testing machines.

Compound Microscope (*Light*). A combination of lenses in which a real and magnified image of an object is formed by one lens (or set of lenses) of short focal length, called the OBJECTIVE; this real image is viewed by a second lens (or set of lenses) called the EYE PIECE, which forms a magnified virtual image of the first image. By this means very high magnification is obtained.

Compound Oils (*Eng., etc.*) A mixture of several oils, which is sometimes used for lubricating. Thus a mineral oil is added to an animal or vegetable oil in order to prevent the latter from becoming too viscous, or in order to prevent decomposition.

Compound Pendulum (*Phys.*) *See* PENDULUM.

Compound Radical (*Chem.*) A group of elements entering into and being expelled from chemical combination like a single element. Thus the groups (CN), (CH_3), (OH) are compound radicals; they form chlorides, hydroxides, etc., like an element.

Compound Table (*Eng.*) A TABLE (*q.v.*) of a machine tool to which motion in two directions can be given: a third motion, one of rotation, is sometimes provided for.

Compound Time (*Music*). *See* TIME.

Compound Train (*Eng.*) A series or set of toothed wheels used on screw-cutting lathes in which there are two or more wheels connecting those on the mandrel and the leading screw of the lathe.

Compound Winding (*Elect. Eng.*) *See* DYNAMOS.

Compressed Air (*Eng.*) Used for driving machinery, for ventilating, or for excluding water in mines, tunnels, and submarine workings. The air is compressed by large pumps, driven by power, in a central engine house, and is led through pipes to the machines. In mining operations the exhaust air, after leaving the machines, helps to ventilate the workings.

Compressed Gases. Various gases can now be obtained compressed into steel cylinders under very high pressure, which may be as much as 1800 lb. per square inch or even more. Large quantities of oxygen and hydrogen are sent out in this way for use with the oxyhydrogen light and for other scientific and commercial purposes. Chlorine (used in gold extraction), carbon dioxide, ammonia, sulphur dioxide, etc., can also be obtained in this form.

Compressed Steel (*Eng.*) Ingots of steel which have been allowed to solidify under pressure. By this means the steel becomes homogeneous, and its strength is very greatly increased.

Compressibility of Gases (*Phys.*) Gases can be compressed to an enormous (though not unlimited) extent. The relation between the pressure and volume is in accordance with Boyle's Law (*q.v.*) so long as the pressure is not too great. *See also* ELASTICITY.

Compressibility of Liquids (*Phys.*) This is very slight, and can only be detected at all by very careful experiments. For practical purposes (in engineering, etc.) it can always be neglected entirely.

Compressibility of Solids (*Phys.*) This varies greatly: it is very small, and therefore may be neglected in the case of metals and many elementary substances, but with substances of complex constitution or of organic origin (such as wood, cork, rubber, etc.), it may become very considerable. *See also* ELASTICITY.

Compression (*Phys., Eng., etc.*) (1) The reduction of the length or other dimensions of a body by the application of external force. (2) The CUSHIONING or shutting in of a small amount of steam in a cylinder just before the return stroke after the exhaust port is closed. (3) The reduction in volume of the charge in a gas engine by the back stroke of the piston before the ignition or firing of the charge. This compression of the charge greatly increases the efficiency of a gas engine, as can readily be found by experiments. In modern engines the charge is often compressed till its pressure is over 80 lb. per square inch.

Compression Engines (*Eng.*) Gas engines in which the charge is subject to compression (*q.v.*) This is now adopted in practically all gas engines.

Compression Line (*Eng.*) *See* INDICATOR DIAGRAM.

Con Amore (*Music*). With love, lovingly.

Con Anima (*Music*). With soul.

Con Brio (*Music*). With brilliancy.

Concave Lens (*Light*). A lens thinner in the centre than at the edges. One face must be concave, the other may be plane, concave, or convex; if the latter form is used, its centre of curvature must be more distant from the lens than that of the concave surface. The focal length of a concave lens is a positive quantity.

Concave Mirror (*Light*). A reflecting surface which is usually a part of a hollow sphere. This does not bring a parallel beam to a true focus. (*See* SPHERICAL ABERRATION.) A PARABOLIC MIRROR (*q.v.*), which has a true geometrical focus, resembles a spherical mirror very closely as far as appearance goes; but its cross section is a parabola instead of a circular arc, thus making it somewhat flatter towards the circumference than a spherical mirror.

Concentric Chuck (*Eng.*) A SELF CENTERING CHUCK (*q.v.*)

Concertina. *See* MUSICAL INSTRUMENTS, WIND (KEYED).

Concord (*Music*). A chord requiring neither preparation nor resolution.

Concordant Intervals (*Music*). Are the perfect eighth, fifth, and fourth, and the major and minor third and sixth; also called CONSONANCES.

Concordant Tones (*Sound*). Two notes or tones which, when sounded together, produce no sensation of roughness or discord due to beats. This is not the same thing as the absence of beats; they may be present, but not sufficiently prominent to be detected by the ear.

Concrete (*Build.*) A mixture of lime or cement mortar with some coarse material, such as broken bricks, stones, slag, coke, etc. It is much used for foundations, heavy masonry, paving and in many kinds of building and civil engineering work.

Concretionary Structures (*Geol.*) These are due in all cases to chemical action; but the precise condition under which these forces act is at present very imperfectly understood. Solutions of various substances that happen to be present in a rock tend to concentrate around some nucleus, which is not uncommonly of organic origin, and the process of aggregation often goes on until the whole of the substance which happens to be within migrating distance of the nucleus has drained from the

surrounding rock and has collected around that point. Flints, nodules of chert, and clay ironstone are familiar examples of concretions.

Condensation (*Chem.*) The union of two or more molecules, which may be the same or different, to form a new molecule, the occurrence generally, but not always, being accompanied by the splitting off of water, alcohol, etc. Substances which induce this kind of change are called CONDENSING AGENTS. Example of condensation :

$$\underset{\text{Aldehyde.}}{CH_3.CHO} + CH_3CHO = \underset{\text{Aldol.}}{CH_3CHOH.CH_2CHO}$$
$$= \underset{\text{Croton aldehyde.}}{CH_3CH:CH.CHO} + H_2O$$

Examples of condensing agents are zinc chloride, hydrochloric and sulphuric acids, aluminium chloride.

—— (*Phys.*) The reduction of a gas or vapour to its liquid form by cold or pressure or both combined. *See also* LIQUEFACTION OF GASES.

Condensed Thread (*Textile Manufac.*) *See* SLIVER.

Condenser (*Light*). A MICROSCOPE CONDENSER is a lens used to produce powerful illumination of the slide or other object which is being viewed. A LANTERN CONDENSER, on the other hand, is not required in order to increase the intensity of illumination of the slide, but to cause the rays to converge after passing through the latter, so that they may also pass through the remaining lenses, which focus the picture on the screen.

—— (*Phys., Eng., etc.*) Any arrangement for condensing gases or vapours. In a steam engine the arrangement for condensing the steam by bringing it into contact with either cold water or a cold surface. The former arrangement, which was the one first used, constitutes an INJECTION or JET CONDENSER; the latter, which is generally used in steamships, is known as a SURFACE CONDENSER (*q.v.*)

—— (*Cotton Spinning*). A machine used in the spinning of coarse waste yarns, attached to a carder for the purpose of splitting up the web from the doffer into strips, and at the same time rolling it into a round strand preparatory to the spinning process. The yarns are called CONDENSER YARNS. *See* CARDING.

—— (*Gas Manufac.*) *See* GAS MANUFACTURE.

—— (*Woollen Manufac.*) The delivering section of a set of carding engines that divide the endless fleece of fibres into soft fluffy threads. *See* CARDING.

——, **Electrical.** Any two conducting surfaces separated by a DIELECTRIC (*q.v.*) A sheet of glass coated on both sides with tinfoil, or a pile of alternate sheets of tinfoil and mica, are common forms. Condensers are used as standards of electrical capacity in various quantitative experiments, and are also used in Induction Coils, Tesla Coils, etc. (*q.v.*)

Condenser Tubes (*Eng.*) Tubes used in SURFACE CONDENSERS (*q.v.*); they are usually brass, ¾ in. and upwards in diameter.

Condensing Agents (*Chem.*) *See* CONDENSATION (*Chem.*)

Conditioning (*Cotton Spinning*). When yarn is taken from the spindles it usually contains about 3 per cent. less than its natural moisture. It is therefore CONDITIONED by keeping a few days in a damp place, so as to regain the loss.

Conductance (*Elect.*) The inverse of resistance: if the resistance of any conductor be r, then its conductance is $\frac{1}{r}$.

Conduction of Electricity. The passage of electricity through the material or over the surface of a body. The nature of the process is well understood in the case of liquids and gases (*see* CONDUCTIVITY OF LIQUIDS), and there are reasons for supposing that the process of conduction in solids may be of a similar nature, *i.e.* it may be due to the action of IONS (*q.v.*) The conductivity of metals is much greater than that of electrolytes, but "there does not seem to be sufficient difference between the *laws* of conduction through metals and electrolytes to make it necessary to seek an entirely different explanation for metallic conduction."—J. J. THOMSON.

Conduction of Heat. The passage of heat through matter, without visible motion of the particles. These particles are probably set in vibration, but do not move permanently from their original positions or acquire a motion of translation, as in CONVECTION (*q.v.*)

Conductivity for Heat, Coefficient of. The amount of heat which flows in unit time through unit area of a layer of substance of unit thickness when unit difference of temperature is maintained between the two sides. If k be this coefficient for any substance in the form of a plate, of area A and thickness d, and if t_1 and t_2 be the temperature at which the opposite sides of the plate are maintained, then the quantity of heat Q which flows through the plate in T seconds is given by the equation

$$Q = k\frac{A(t_1 - t_2)T}{d}.$$

Conductivity of Liquids (*Phys.*) As a rule the electrical conductivity of liquids depends upon charges of electricity being carried through the liquid by the formation of IONS (*q.v.*) in the liquid. These are atoms, or groups of atoms, into which substances in solution or liquid are broken up by the action of the electricity. Water, if pure, conducts little, if at all; but the addition of any substance which can be split up into ions, such as a mineral, acid, or salt, renders it a good conductor. This process is thus analogous to CONVECTION (*q.v.*)

Condy's Fluid (*Chem.*) A liquid prepared by adding potassium permanganate to aluminium sulphate solution. It is a good disinfectant.

Cone (*Math.*) A geometrical solid produced by the rotation of a triangle about one side.

—— (*Eng.*) A stepped driving pulley (*q.v.*)

—— (*Met.*) The cap or cover of a blast furnace (*q.v.*)

Cone Bearing (*Eng.*) A bearing in which a solid cone on the shaft or spindle runs in a bearing formed by a hollow cone of hard steel or brass; commonly used in lathes as a bearing for the mandrel.

Cone Clutch (*Eng.*) A friction clutch in which the respective parts of the shaft carry a hollow and a solid cone, one fitting into the other. These are caused to turn together by the friction between the surfaces when they are brought into close contact. A cone clutch can be thrown in or out of gear without any sudden shock to the mechanism with which it is connected.

Con Energia (*Music*). With energy.

Cone Plate (*Eng.*) A vertical plate fixed on the lathe bed to support the end of cylindrical work, the free end of which revolves in a tapering hole in the plate, thus dispensing with the use of the back centre, and allowing boring tools or drills to be inserted through the hole in the plate, in order to act on the work as it rotates.

Con Espressione (*Music*). With expression.

Conformable Succession (*Geol.*) Successive beds of rock which have been formed over the same spot one after the other (without any important interruption or hiatus, representing strata which have been deposited in the meantime elsewhere) are said to be in conformable succession. If an older set of rocks has undergone disturbance, so as to be tilted from its original position, then partly denuded, and another set of rocks deposited across their edges, the succession is said to be UNCONFORMABLE. The relationship implies lapse of time.

Con Forza (*Music*). With force.

Con Fuoco (*Music*). With fire : passion.

Congé (*Architect.*) *See* APOPHYGE.

Conger Eel. *Conger vulgaris* (family, *Murænidæ*). The conger is closely allied to the true eel, and its flesh is much used for making soups.

Conglomerate (*Geol.*) An indurated rock formed of rounded and sub-angular fragments of derivative origin, worn by the action of water and afterwards compacted by some cementing material. When the fragments are angular, the rock is distinguished as a BRECCIA. AGGLOMERATE is always of volcanic origin.

Congo Red (*Chem.*)

$$\begin{array}{l} C_6H_4 \underset{(4)}{-} N : N \underset{(2)}{-} C_{10}H_5 \left\langle \begin{array}{l} NH_2 \ (1) \\ SO_3Na \ (4) \end{array} \right. \\ (1) \,| \\ C_6H_4 \overset{(4)}{-} N : N \overset{(2)}{-} C_{10}H_5 \left\langle \begin{array}{l} NH_2 \ (1) \\ SO_3Na \ (4) \end{array} \right. \end{array}$$

A reddish-brown powder. The salt is soluble in water, but the free acid is only soluble with difficulty, and is blue in colour. It is obtained by union of tetrazodiphenyl—from benzidine (*q.v.*)—with α-naphthionic acid. It dyes wool or cotton red, but the colour is changed to bluish shades by acids. It is important as an INDICATOR (*q.v.*) Alkalis turn it a brilliant scarlet, while acids turn it blue : an alcohol solution must be used. It is also used as a stain in Bacteriology. *See also* DYES AND DYEING.

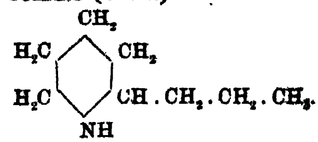
Con Grazia (*Music*). With grace.

Conical. In the form of a CONE (*q.v.*)

Conical Spring (*Eng.*) A spring produced by winding a strip of metal on the surface of a cone: often used in buffers, etc.

Conical Turning (*Eng.*) The production of taper work, usually effected by setting the loose headstock or poppet of a lathe out of the line of centres, and then taking a cut parallel to the bed with the slide rest. As the point of the tool moves parallel to the axis of the lathe bed, the surface of the work will be turned in the form of a cone. In other cases, when a short cone of large vertical angle is required, the upper part of the slide rest is set at an angle with the bed.

Conine, Coniine (*Chem.*)



An alkaloid: the poisonous principle of HEMLOCK. A colourless liquid; faint mousy odour, alkaline, dextro-rotatory, sparingly soluble in water (1 in 90). It is a powerful poison, affecting the motor nerves so that the limbs become paralysed. It is obtained by treating the juice from hemlock seeds with alkali, distilling in steam, and purifying the crude distillate. It has been prepared synthetically, and its constitution is proved by heating it with hydriodic acid, when it yields ammonia and normal octane.

Coning (*Eng.*) Forming the rims of railway wheels in the shape of part of a cone. This taper or conical form facilitates the turning of curves on the line.

Conjugate Conductors (*Elect.*) Two conductors are said to be conjugate if they are connected (by other conductors) in such a manner that an electromotive force in one of them does not produce any current in the other. *See also* WHEATSTONE'S BRIDGE.

Conjugate Foci (*Light*). Two points such that light diverging from one of them and falling on a lens or mirror, either *converges to* the second (which is then termed a REAL IMAGE of the first) or else appears to *diverge from* the second (which is called a VIRTUAL IMAGE of the first point).

Conjunction (*Astron.*) The position of a planetary body when its elongation (*q.v.*) is zero, *i.e.* when its longitude equals that of the sun; *e.g.* the moon is in conjunction with the sun at NEW MOON.

Con Moto (*Music*). With motion.

Connecting Rod (*Eng.*) A rod which transmits the motion of the piston rod to the crank pin of an engine. *See* STEAM ENGINE, *etc.*

Connective Tissue (*Zoology*). The term applied to a thin membranous tissue, consisting of irregular cells and fibres in a soft gelatinous matrix. This tissue covers and supports all the organs of the body.

Connector (*Gasfitting*). A socket on a pipe with a long thread and a back-nut; it serves to make a joint or connection between two pieces of barrel or piping, either of the same or of different diameters.

Connemara Marble. *See* BUILDING STONES.

Connoisseur. A good judge of some branch of the fine arts : one having a critical knowledge of works of art.

Consecutives (*Music*). Intervals occurring between the same parts or voices.

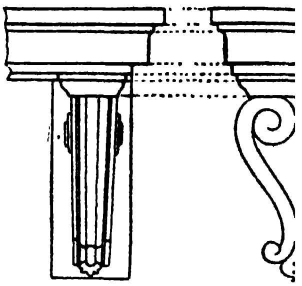
Consequent Poles (*Elect. Eng.*) Consequent poles may be regarded as poles (*q.v.*) produced by the junction of two or more similar poles; they are frequently employed in the magnetic circuit (*q.v.*) of dynamos. The magnetising coils are in pairs, one coil being on either side of each pole piece, and the magnetising forces of these two coils act in opposite directions. The effect is analogous to that produced by two cells in parallel (*q.v.*); the lines of force correspond to the electric current, and that part of the

magnetic circuit which consists of the armature and the two pole pieces corresponds to the external circuit in the case of the two cells. *See also* DYNAMOS.

Conservation of Energy (*Phys.*) Energy may be communicated from one body to another, or it may be changed from one form to another, but it can neither be created nor destroyed.

Console. A table supported by two legs placed in front, the back being fastened to the wall.

—— (*Architect.*) An ornamental bracket or corbel. *See* MODILLIONS, *etc.*



CONSOLE (*Architect.*)

Consolidation of Strata (*Geol.*) Fragmentary or clastic rocks are in some cases compacted into hard masses by the mere pressure of thick piles of other rocks which have been deposited over them. But more generally their consolidation is due to the infiltration of waters holding in solution various mineral substances which have been eventually deposited as a cement between the particles. Lime, iron, silica are common substances deposited in this way.

Consonance (*Music*). *See* CONCORD.

—— (*Sound*). The effect of CONCORDANT TONES (*q.v.*)

Con Spirito (*Music*). With spirit.

Constant (*Eng.*, *Physics*, *etc.*) A coefficient, used in various formulæ, which depends on the dimensions, form, or nature of the substance or the material to which the formula refers. A constant may either be capable of being calculated or be a quantity which can only be found by experiment.

Constant Current (*Elect. Eng.*) (1) A current whose amount or value is allowed to vary as little as possible. (2) A CONTINUOUS CURRENT, as distinguished from an alternating current, is often (though not very correctly) termed a constant current.

Constant Voltage (*Elect. Eng.*) An electrical pressure or voltage kept at a uniform value, as, for example, when it is required to supply a number of lamps in parallel, so that the actual current in each lamp does not vary, even though the number of lamps is altered. The ordinary house supply of electricity is always on the constant voltage system.

Constitution (*Chem.*) The arrangement of the atoms of the elements to form a molecule of a compound. Thus, carbon monoxide has the formula CO, as is proved by analysis and the agreement of this formula with the observed vapour density; it unites with its own volume of chlorine in sunlight, and so the most probable CONSTITUTION of the product (carbon being tetravalent) is $O = C \langle {Cl \atop Cl}$. When this gas is treated with ammonia we get hydrochloric acid and urea. Hence we infer the constitution of urea is $O = C \langle {NH_2 \atop NH_2}$.

Constitutional Formulæ (*Chem.*) *See* CHEMICAL FORMULA.

Contact Difference of Potential (*Elect.*) When two metals are placed in contact, there is a small potential difference (*q.v.*) between them, which is independent of the extent of surface in contact, but depends on the physical and chemical nature of the metals. Contact differences of potential also occur between other substances; the most important cases in practice are those of the metals and carbon in contact with various acids.

Contact Metamorphism (*Geol.*) A term applied to the changes which are brought about in rocks by the chemical action of the heated waters which are present where eruptive rocks are in process of formation. Solution of certain constituents, recombination, and incipient crystallisation result from these causes; and the process may be continued in some cases so far that more or less complete metamorphosis of the rocks affected may result. The nature of the new minerals developed by the change is largely dependent upon that of the original substances acted upon.

Contact Printing (*Photo.*) The usual printing processes in photography in which the sensitised surface is placed in contact with the negative to be copied during the exposure to light.

Contact Vein (*Mining*). A vein which occurs between two different kinds of country rock (*q.v.*)

Contagion (*Hygiene*). When disease is communicated from one person to another by actual contact, the term CONTAGION is used. It is employed in a sense distinct from INFECTION. By this latter term is meant the transmission of disease through the medium of air, food, water, etc. Some diseases are both contagious and infectious.

Contemporaneous Erosion (*Geol.*) Where sedimentary rocks are in process of formation on the land or in shallow water, it frequently happens that a portion which has only lately been deposited, may locally undergo removal. Sandbanks in deltas, or near the mouth of rivers, are particularly liable to such accidents, which may happen again and again on the same spot, even within a short space of time. Hence the phenomenon does not necessarily afford any indication of a lapse of time, as does that of UNCONFORMITY (*q.v.*)

Con Tenerezza (*Music*). With tenderness.

Continuous Alternating Transformer (*Elect. Eng.*) A combination of a motor and a dynamo, often with the armatures on the same shaft, or even with a single armature for turning a continuous into an alternating current, or *vice versa.*

Continuous Beam (*Eng.*) A beam which rests upon more than two supports. The stresses, deflection, etc., are calculated by means of the theorem of THREE MOMENTS (*q.v.*)

Continuous Brake (*Eng.*) A brake which is applied to a number of wheels simultaneously, and is controlled from one point.

Contortion of Strata (*Geol.*) Piles of strata which have been deposited in horizontal positions may be carried downward by subsidence of the earth's crust, and thus be subjected to lateral (as well as vertical) compression. A continuance of the process bends the strata into folds, which may eventually be so closely pressed together that crumpling and contortion may result. Fine examples may be met with in almost any region where the strata have undergone much disturbance.

Contour (*Art*). (1) The outline of a figure: the expression is generally used when speaking of rounded or sinuous bodies. (2) The line dividing the different coloured parts of a design.

Contourné (*Her.*) Reversed on the field, as when a beast is represented with its face towards the sinister side.

Contours (*Surveying*). Lines joining all points at the same given height above an assumed level, called the DATUM LINE or DATUM LEVEL.

Contraction. The diminution in length, area, or volume of a body, however produced.

Contraction of Area (*Eng.*) This applies specially to the diminution of the cross section of a bar at the point where it contracts in a testing machine. The greater the amount of the contraction the better the material, as a general rule.

Contraction Rule (*Pattern-Making*). A pattern-maker's measuring rule, on which all dimensions are increased in proportion to the amount of contraction which a casting will undergo in cooling: ·1 in. per foot in iron, and ·15 in. in brass, is usually provided for.

Contralto (*Music*). The lowest of the voices of women.

Convection Currents (*Heat*). *See* CONVECTION OF HEAT.

Convection of Heat. The passage of heat through liquids and gases by the actual motion of streams of heated particles, which, being lighter than the surrounding fluid, tend to rise as " Convection Currents." Convection usually plays a more important part than conduction in the spread of heat through a fluid; water, for example, is so bad a conductor that if a comparatively short column be heated at the top, the upper layers can be made to boil, while the lowest layers are kept almost at freezing point.

Converter (*Metallurgy*). *See* BESSEMER CONVERTER *and* STEEL.

Converters (*Elect.-Eng.*) TRANSFORMERS (*q.v.*)

Converting (*Metallurgy*). The manufacture of steel from wrought iron by the cementation process, but also applied to the Bessemer process (*q.v.*) *See also* STEEL.

Convex Lens (*Light*). A lens thickest in the centre. One face must be convex, the other may be plane, convex, or concave. A convex lens gives a real image of an object which is farther off than its First Principal Focus, and a virtual image of an object which is nearer.

Convex Mirror (*Phys.*) A reflecting surface, convex in form, and usually forming part of the surface of a sphere. The focal length is negative.

Cooking (*Hygiene*). The object of cooking is to render food more digestible and palatable. It also destroys any bacteria or parasites which may be present in the food. The ordinary methods of cooking are boiling, broiling, stewing, roasting, baking, and frying. All cooking utensils should be kept scrupulously clean.

Cooling (*Eng.*) The cooling of cast or forged metal work should in general be gradual, as this prevents the setting up of internal stresses and greatly increases the strength of the object.

Cooling Gas Engines. *See* PETROL ENGINES *and* GAS ENGINES.

Cooling, Newton's Law of (*Heat*). The rate at which a body cools is proportional to the difference in temperature between it and the medium in which it is placed. This law is only true when the differences of temperature are not very large.

Cooper's Ventilator (*Hygiene*). The purpose of this is to act as an outlet for the vitiated air. It is constructed on the " hit and miss " principle, and consists of several small pieces of glass fitted over similar sized openings in the pane of the window.

Cop (*Cotton Spinning*). The cylindrical form in which the yarn is built up when spun on the mule. It consists of a rounded bottom, with the top or finishing part cone shaped. There are three sizes of cop spun, *viz.* (1) Pin cop, (2) Bastard cop, (3) Twist cop.

—— (*Woollen Manufac.*) The conical form in which the yarn is spun on the self-actor (*q.v.*)

Copal. The term copal is applied to a number of semi-fossil resins, mostly derived from a tree, *Trachylobium verrucosum* (*Leguminosæ*), grown in Africa. The resin is found in the soil near the roots. It is largely used in the manufacture of the best varnishes. The most esteemed variety for this purpose is Sierra Leone copal, which requires a temperature of 400° F. to melt it. From it is obtained pale and very durable varnishes.

Copaline (*Min.*) One of the Bitumens (*q.v.*) It is a carbon compound with hydrogen and oxygen. Pale yellow, waxy, occurring in small fragments at Highgate Hill, London; also called HIGHGATE RESIN.

Cope (*Foundry*). The upper part of a mould.

—— (*Cost.*) An ecclesiastical vestment semicircular in form and resembling a cloak. It is worn by all grades of the clergy and sometimes by choirmen or cantors. Often embroidered, hooded, and adorned with orphreys, fastened by a clasp. It is distinguished from the chasuble as being processional, the chasuble (*q.v.*) being eucharistic.

Coping (*Build.*) The projecting course on the top of a wall.

Copper, Cu. Atomic weight, 63·6. A brownish red metal: melts at about 1050°: tough, malleable, ductile (sp. gr. 8·9). It is the best conductor of electricity known, and next to silver the best conductor of heat. In dry air it undergoes no change, but in moist air it becomes covered with a film of basic carbonate of copper. Hydrochloric acid has scarcely any action upon it, unless the metal is very finely divided, when cuprous chloride and hydrogen are produced. Sulphuric acid does not act upon it in the cold, but the hot concentrated acid forms copper sulphate and sulphur dioxide; nitric acid, except when very pure, dissolves it readily, forming copper nitrate and nitric oxide principally, but also some nitrous oxide and nitrogen. Copper displaces mercury, silver, and gold from their solutions. It enters into the composition of many important alloys —*e.g.* brass, bell metal, gun metal, bronze, German silver, platinoid, etc. The principal ores of copper are COPPER PYRITES, GREY COPPER ORE, CUPRITE, COPPER GLANCE, MALACHITE, AZURITE (*q.v.*); it also occurs in a free state, especially on the southern shore of Lake Superior. In Wales the metal is extracted as follows: (1) The ore is carefully roasted to expel a part of the sulphur and arsenic which is present in it, much of the iron sulphide forming iron oxide, while only a little of the copper

sulphide is oxidised. (2) This product is now melted to cause the union of the oxide of iron with silica of the ore, and slag containing copper, termed METAL SLAG, from the fourth operation is added. The result of the operation is a slag of iron silicate, termed ORE FURNACE SLAG, and a product called COARSE METAL, consisting of copper, iron, and sulphur. (3) The roasting process is now repeated. (4) The product is again melted, with the addition of ROASTER SLAG and REFINERY SLAG from the next two processes. As the result of this last fusion the METAL SLAG is produced, which is used in Operation 2, and a product called FINE METAL, WHITE METAL, or BLUE METAL obtained, which is practically cuprous sulphide (Cu_2S), with small quantities of other sulphides, such as iron. (5) This FINE METAL is now partially oxidised, then melted, when the oxides and sulphides react to produce copper and sulphur dioxide. This impure copper is called BLISTER COPPER, because its surface is blistered, owing to escape of sulphur dioxide as the metal solidifies. (6) The blister copper is now REFINED by being carefully roasted (exposed to oxidising action of air) to a certain extent and then melted. When melted, powdered anthracite is thrown on the surface, and poles of green wood are plunged into the molten metal, the object being respectively to prevent further oxidation and to reduce copper oxide, which exists dissolved in the melted metal. The refined copper is called TOUGH PITCH COPPER. If the "poling" is insufficient the metal is brittle or DRY. It is also possible to "overpole" the copper, when it again becomes brittle. All the above processes are carried out in reverberatory furnaces (*q.v.*) In America, blast furnaces of the RASCHETTE type (*q.v.*) are very largely used to produce a rich copper sulphide; and Bessemer converters (*q.v.*) are used to produce copper from the rich sulphide; but the blast is introduced at the sides. Much copper is also produced from Spanish pyrites, which have been burned by the sulphuric acid manufacturer. The burnt pyrites are roasted with common salt and then dissolved in water; to the solution zinc iodide is added to precipitate silver, which is recovered from the silver iodide; and from the solution the copper is precipitated by scrap iron, the precipitated metal being subsequently melted and refined like blister copper. The refining of copper is now carried out extensively by electrolysis. The impure copper (*e.g.* blister copper) is cast in slabs, which are suspended in a solution of copper sulphate contained in insulated, lead lined, wooden vessels. The slabs are connected to the positive pole of a dynamo, while the negative pole is connected to a thin sheet of pure copper, also suspended in the copper sulphate solution at a short distance from the slab. A current of small density and low voltage is used, and pure copper is deposited on the thin plate or Cathode. The impurities are deposited as a mud at the positive pole, and from the mud gold is recovered in many cases

Copper (*Min.*) This element occurs in the native state in films in some sandstones and in groups of octahedra. It sometimes contains small traces of silver or bismuth. Found in Cornwall, Devonshire, Wicklow, Siberia, Burra-Burra in Australia, and in large quantities at Lake Superior. A great number of minerals contain copper in combination; among the more important are Copper Pyrites, Malachite, Azurite, Cuprite, Tetrahedrite, Melaconite, Bournonite, Tenorite, Dioptase, Chrysocolla, Brochantite, Chalcanthite, Chalcocite, Erubescite, and Stannite.

Copperas (*Min.*) A naturally occurring hydrous sulphate of iron, $FeSO_4 . 7H_2O$. Iron = 25, sulphuric acid = 29, water = 45 per cent.. Also called MELANTERITE. In monosymmetric crystals, green, yellow, or white. More often in encrusting masses or as an efflorescence on pyrites, from the decomposition of which it results. Ohio and Goslar in the Harz, etc. The name Copperas is often applied in commerce to ordinary sulphate of iron.

Copper Bit *or* **Soldering Iron.** A pointed copper tool which is heated and used to melt the solder in making a joint.

Copper Compounds. Copper forms two series of compounds known as the cuprous and cupric compounds. CUPROUS OXIDE, Cu_2O: A red powder used in making ruby glass. It is made by heating a solution of copper sulphate containing excess of caustic soda and some tartaric acid with glucose (*see* Fehling's solution). CUPROUS CHLORIDE, Cu_2Cl_2: A white crystalline solid insoluble in water, soluble in hydrochloric acid, also in ammonia. It is made by dissolving cupric oxide in excess of strong hydrochloric acid, and boiling the solution with copper: when the liquid is nearly colourless it is poured into a large quantity of water. CUPRIC OXIDE, CuO: A black powder; hygroscopic; insoluble in water, but soluble in acids forming cupric salts. It is made by heating the metal in air (*e.g.* scale on a copper kettle) and by heating the nitrate. It is used in colouring glass green, and in organic analysis, because when heated with an organic compound it converts the carbon to carbon dioxide and the hydrogen to water. CUPRIC SULPHATE, $CuSO_4$: A white solid which readily absorbs water, becoming blue and forming BLUE VITRIOL, $CuSO_45H_2O$; it is made by heating the latter compound, and is used to detect the presence of water in so-called absolute alcohol. Crystallised copper sulphate, $CuSO_45H_2O$ (blue vitriol), is obtained from solution of copper sulphate in water by allowing it to crystallise. This solution may be prepared by dissolving the oxide in dilute sulphuric acid, or by heating the metal with concentrated sulphuric acid, adding water when cool, and filtering. On the large scale copper pyrites ($CuFeS_2$) is heated in air in such a way as to form copper sulphate and ferric oxide the product is extracted with water and carefully crystallised. It is used in electrotyping, in the Daniell's cell, in dyeing and calico printing, in preserving grain from "smut," and in colouring bottled peas green. Copper and copper compounds, when heated in the non-luminous gas flame, impart to it a characteristic green or blue colour. Zinc, iron, and magnesium throw out copper from solutions of its salts, an equivalent of the metal taking its place.

Copper Drift (*Eng.*) A piece of copper with a flexible handle, which is placed on finished metal work when it is struck with a hammer, in order to prevent injury to the surface.

Copper Glance (*Min.*) A cuprous sulphide, Cu_2S. Copper = 79·8, sulphur = 20·2 per cent. Also called REDRUTHITE and VITREOUS COPPER ORE. In twinned crystals of the rhombic system; also massive. Lead colour or with a greenish tarnish. It is a valuable ore, on account of its high percentage of copper. From Cornwall, Devon, Siberia, Saxony, Thuringia, North and South America, etc.

Copper Losses (*Elect. Eng.*) The waste of energy through the resistance of copper circuits in electric plant. The energy is dissipated in the form of heat.

Copper Nickel (*Min.*) A synonym for KUPFERNICKEL (*q.v.*)

Copper Pipe (*Eng.*) Extensively used for the steam pipes of large engines, etc. It can expand and contract during changes of temperature without tearing or cracking.

Copperplate. A polished plate of copper with bevelled edges, upon which an engraving is executed. *See* ENGRAVING AND ETCHING.

Copper Pyrites (*Min.*) A sulphide of iron and copper, $Cu_2S.Fe_2S_3$. Copper = 32 to 34, iron = 29 to 31, sulphur = 34 to 36 per cent. Also called CHALCOPYRITE. The commonest form of crystal is a twin of tetragonal tetrahedra. Also massive. Colour, brassy yellow, often with a darker tarnish. Very brittle, softer than iron pyrites, which it externally resembles. The chief ore of copper. Cornwall, Cumberland, Devon, Sweden, the Harz, etc.

Copper Uranite (*Min.*) A hydrous phosphate of copper and uranium, $(CuO.2U_2O_3)P_2O_5.8H_2O$. Uranic oxide = 59 to 61, phosphoric acid = 14 to 16, oxide of copper = 8·5 to 9, water = 14 to 15 per cent. Also called Torbernite, Chalcolite, and Uranmica. Occurs in implanted tabular tetragonal prisms of an emerald green colour. Cornwall, Devon, Saxony, and Bohemia.

Copping Rail (*Cotton Spinning*). An attachment on the mule which is connected to the faller wire for determining the chase or building up of the cylindrical body of a COP (*q.v.*)

Copra. The dried kernels of the cocoanut palm, *Cocos nucifera* (*Palmæ*), imported into this country. Under pressure, copra yields cocoanut oil, used in the manufacture of candles.

Coprolite (*Geol.*) A term correctly applied only to the fossil remains of the droppings of fish. Such exuviæ generally contain more or less of phosphatic matter, which is of great value, if obtained in sufficient quantities, for artificial manures. As a consequence, coprolites have been much in request for that purpose, and when other substances which afford the desired phosphatic matter have been met with, the term coprolite has been applied commercially to these, quite irrespective of their origin.

Copy (*Art*). The reproduction of an original picture or work of art. When an artist copies his own production it is termed a REPLICA.

—— (*Typog.*) Manuscript, typewritten, or printed matter handed to a compositor to be set in type.

Copying (*Photo.*) Effected either by making an ordinary negative with the camera or by some form of contact printing. The latter is very easily applied to tracings, and is generally carried out by some form of BLUE PROCESS (*q.v.*)

Copying Machine (*Eng.*) A machine for the production of a large number of similar objects by a tool, guided in a suitable manner by an automatic device.

Copyright (*Literary and Artistic*). Copyright is "personal" property, and may be defined as the sole right to produce, after publication, copies of a book, article, lecture, play, musical composition, painting, drawing, print, photograph, or a piece of sculpture. "Publication," in most of these instances, consists of tendering a work for sale publicly; in the case of a piece of sculpture it is effected by the exhibition of the work. With respect to lectures and plays, a dual right exists: (1) publishing, (2) delivering or performing. Before publication the author may restrain anyone else from publishing his work by an action at common law. The copyright of a work first published in the United Kingdom extends to all parts of the British dominions, but is subject in certain details to the local laws. In the United Kingdom, COPYRIGHT IN BOOKS lasts for forty-two years from the date of publication, or, in the event of the author dying, for the period covering his life, plus a period of seven years, should the two periods not exceed forty-two years. As regards POSTHUMOUS BOOKS, copyright dates from publication. The copyright of articles appearing in magazines and periodicals, unless otherwise stipulated, vests for a period of twenty-eight years in the editor or proprietor engaging and paying the writers of the articles; but such articles may not be published separately. In the case of PAINTINGS, DRAWINGS, and PHOTOGRAPHS, the right lasts for the life of the author, plus a period of seven years; and in the case of PRINTS the period is twenty-eight years. For SCULPTURE the period is fourteen years, plus a further similar period if the author be living at the end of the first period. Copyright in PLAYS extends for the same period as that in books. This is also the case with MUSIC. In the UNITED STATES, copyright lasts for a period of twenty-eight years, plus a period of fourteen years on re-registration; but to secure copyright for a British book it must be published simultaneously in both countries. Those countries which are signatories to the BERNE CONVENTION OF 1887, supplemented by the ACT OF PARIS OF 1896, are bound to secure for an author, who is a subject of any one of them, the same rights as the laws of his own country afford. The following countries form this union: The British Empire, Belgium, Germany, France, Hayti, Italy, Japan, Luxemburg, Monaco, Norway, Spain, Switzerland, and Tunis. Austria and Hungary have a separate convention with Great Britain.

Coquerelles (*Her.*) A French heraldic charge. Three filberts in their husks, conjoined.

Coral. A term generally applied to the hard and usually calcareous substance secreted from sea-water by the action of the coral animals, which belong to the Coëlentera. A great variety of substances have been thus formed, amongst which may be mentioned the PRECIOUS CORAL, the ORGAN PIPE CORAL, innumerable forms of coral structures which go to form coral reefs, and many other structures.

Corallian (*Geol.*) A subdivision of the Oolitic or Jurassic rocks, so called because the remains of the hard parts of various extinct forms of Coëlenterate animals are met with in the rocks on this horizon in the part of England where the rock first received the attention of geologists.

Coralline Crag (*Geol.*) *See* CRAG.

Coralline Oolite (*Geol.*) Another name for CORALLIAN (*q.v.*)

Corbel (*Architect., Build., etc.*) A projection from a wall to support a load.

Corbelling (*Build.*) Courses of bricks oversailing each other; also the supporting of some part of a building by means of corbels.

Corbel Table (*Architect.*) A series of corbels supporting an overhanging parapet; used in Norman and Early English work. In castles and fortifications the parapet and corbels were so arranged that missiles could be thrown from behind the parapet through openings between the corbels. These openings are known as MACHICOLATIONS.

Corbie Step Gable (*Architect.*) A gable formed with a series of steps. It is also known as a Crow-step Gable.

Cordite. *See* EXPLOSIVES.

Cordon (*Her.*) Used in French heraldry. A cord with tassels surrounding the shield of an ecclesiastic.

Cordovan (*Leather*). Cordovan leather is prepared from the skins of goats, formerly from horse hides. It is used in bookbinding and for boots and shoes.

Corduroy (*Cotton Weaving*). Literally king's cord. A form of weft pile weaving for heavy cloths, suitable for men's wear, which gives a rib longitudinally in the cloth. After weaving, it is cut, sheared, and finished. Often dyed.

Core (*Build.*) (1) The filling between a relieving arch (*q.v.*) and the wood lintel. (2) The mortar projecting from the joints inside a flue. (3) Broken stone, bricks, and other building materials used in filling up hollows in the ground, etc.

—— (*Carp., etc.*) The iron bar used to strengthen a wreathed handrail, etc.

—— (*Foundry*). A mass of sand or loam formed in the shape of a cavity, which has to be produced in a casting. The core is either struck (*see* CORE BAR) or produced in a core box (*q.v.*), and is fixed into the recesses in the mould produced by core prints (*q.v.*) When the casting is complete the core is extracted from the cavity in the metal by being broken up and removed piecemeal.

Core Bar (*Foundry*). An iron bar round which a cylindrical core is formed. For large cores of circular section no core box is used, but the bar is coated with foundry sand and loam, and "struck" to shape by rotating it against the edge of a suitably formed board, called a CORE BOARD or LOAM BOARD.

Core Box (*Pattern Making*). A wooden structure containing a cavity (similar to one required in a casting) in which the core is formed by ramming in core sand (*q.v.*) The box can be taken to pieces and the core removed without injury.

Cored Hole (*Eng., etc.*) Cast holes (*q.v.*)

Core Discs (*Elect. Eng.*) Discs of soft iron from which the hollow cylinder forming the core of an armature is built up.

Core Oven (*Foundry*). An oven for drying cores before placing in the mould.

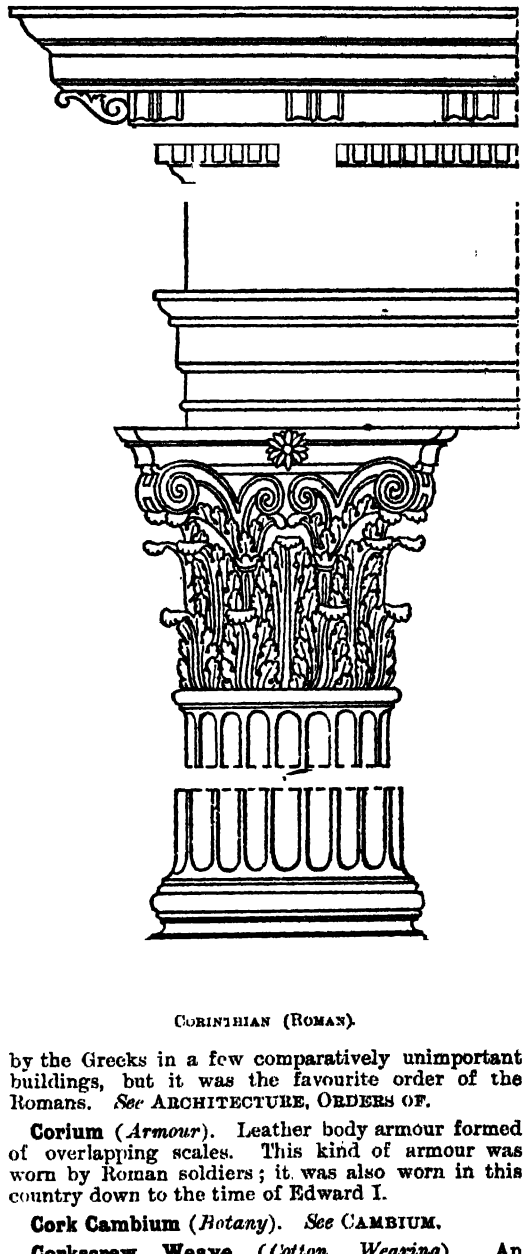
Core Plates (*Foundry*). Thin disc-shaped castings which are fixed on a core-bar in order to serve as a support for large cores. They are broken up when the removal of the core has to be effected.

Core Prints (*Pattern Making, etc.*) Projections on a pattern which form recesses in the mould into which the ends of a core (*q.v.*) are fitted. The length of the core is adjusted to equal the combined length of the hole in the casting, together with the two prints; *i.e.* a core for a hole 9 in. long, if each print were $1\frac{1}{2}$ in., would be 12 in.

Core Sand (*Foundry*). A mixture of sand with some substance to render it porous and to enable it to harden on drying.

Corf (*Met. and Mining*). A shallow basket used for handling minerals in mines. In some districts (chiefly South Yorkshire and Staffordshire) applied to a colliery "tub" (*q.v.*) and spelled CORVE.

Corinthian Order (*Architect.*) The lightest and most ornate of the classic orders. It was only used



CORINTHIAN (ROMAN).

by the Greeks in a few comparatively unimportant buildings, but it was the favourite order of the Romans. *See* ARCHITECTURE, ORDERS OF.

Corium (*Armour*). Leather body armour formed of overlapping scales. This kind of armour was worn by Roman soldiers; it was also worn in this country down to the time of Edward I.

Cork Cambium (*Botany*). *See* CAMBIUM.

Corkscrew Weave (*Cotton Weaving*). An elongated twill, travelling at a greater angle than an ordinary twill.

Corliss Engine (*Eng.*) An engine fitted with Corliss gear (*q.v.*) instead of a slide valve of the ordinary type.

Corliss Gear and Valves (*Eng.*) A form of valve gear used in many large stationary engines. Two valves are placed at each end of the cylinder. Each valve is usually a segment of a circle, and uncovers its port or opening by revolving when acted upon by a series of levers driven from the engine; disc valves and double-beat valves are also used. One valve at each end is an exhaust valve, and opens fully and practically instantaneously, thereby allowing a free escape of steam. When the exhaustion is completed the valves are closed instantly by some form of spring. The remaining valves admit the steam, and the rate at which they open is controlled by the governor. These arrangements secure great regularity and economy in the action of the engine.

Corm (*Botany*). An underground bud whose disc (stem) is much swollen with reserve material. The scale leaves are thin and sheathing. It is often mistaken for a root.

Cornbrash (*Geol.*) One of the subdivisions of the Oolites, which, in the district where it is typically developed, consists very largely of broken and comminuted fragments of shells and other calcareous matter.

Cornea (*Zoology*). The transparent portion of the sclerotic (*q.v.*) coat of the eye.

Corner Cramps (*Join.*) Cramps for drawing up the corners of picture frames, etc.

Corners (*Bind.*) (1) The material covering the corners of "half-bound" books. (2) The triangular tools used in gold or blind tooling.

Cornet. *See* MUSICAL INSTRUMENTS, WIND (BRASS).

Cornice (*Architect.*) A projecting moulding crowning the feature to which it is applied. The cornice of an order is the subdivision of the entablature above the frieze. *See* ENTABLATURE *and* ARCHITECTURE, ORDERS OF.

Cornish Boiler. *See* BOILERS.

Cornish Engine. A large type of beam engine commonly used for pumping. *See also* STEAM ENGINE.

Cornish Granite. *See* BUILDING STONES.

Corn Oil. A product of Indian corn or maize (*Zea mais*) which is extensively grown in the United States, and there eaten as a vegetable. The oil is clear yellow, and is used to a limited extent in paint manufacture. It will not, however, dry unless a liberal amount of driers is added.

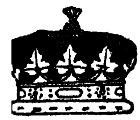
Cornucopia (*Art*). An ornament in the form of a wreathed horn overflowing with fruit and flowers. Symbolical of peace and prosperity, and generally an attribute of figures emblematical of plenty, liberality, etc.

Corona (*Architect.*) The lower part of the projecting portion of a Greek, Roman, or Renaissance cornice. It consists of a vertical face and a soffit (*q.v.*) The latter is recessed upwards so as to form a drip. *See* CORNICE, ENTABLATURE, COLUMN, BED MOULD, *etc.*

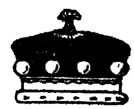
Coronæ (*Meteorol.*) Coloured rings seen round the moon (or more rarely, the sun) when viewed through a mist or thin cloud. They are due to DIFFRACTION (*q.v.*)

Coronet. An inferior crown worn by princes and the nobility, and denoting a dignity below that of the sovereign. It varies in form according to rank. That of the Prince of Wales bears on the edge four crosses "pattée" between the same number of fleurs-de-lis, and from two opposite crosses there rises an arch, surmounted by an orb and a cross. The coronet of a duke bears strawberry leaves; that of a marquis strawberry leaves alternately with pearls; that of an earl has the pearls raised above the leaves; that of a viscount is surrounded by pearls; that of a baron has six pearls only.

PRINCE OF WALES' CORONET.



DUKE'S CORONET.



BARON'S CORONET.

—— (*Her.*) The ensign of princely and noble rank.

Corozo Nut. The seed of a South American tree, *Phytelephas macrocarpa*, allied to the palms. The hardened albumen of the nut furnishes VEGETABLE IVORY.

Corpuscle (*Biology*). The solid bodies suspended in the blood. There are two kinds: (1) RED CORPUSCLES are flat discs, varying in size and structure according to the animal in which they occur. They are very numerous; in man there are about 5,000,000 per cubic millimetre. (2) WHITE CORPUSCLES or LEUCOCYTES are true animal cells, resembling the organism Amœba. Their number is about $\frac{1}{500}$ that of the red corpuscles. *See also* BLOOD *and* HÆMOGLOBIN.

—— (*Elect.*) An ELECTRON (*q.v.*)

Corpuscular Theory of Light. A theory (held by Newton) that light was due to particles emitted by luminous bodies; also known as the Emission Theory. It is now replaced by the Wave or Undulatory Theory. Many of the characteristics of Newton's theory are retained, however, if it is remembered that "the things emitted are Faraday Tubes" (*q.v.*) instead of material particles.—J. J. THOMSON.

Corrections (*Typog.*) Emendations made on a proof (printed sheet) before it is finally printed off. They should be made on the margin of the sheet and against the line where the faults occur. *See* PROOF CORRECTIONS.

Corrector of the Press (*Typog.*) A proof reader.

Corrosion (*Eng.*) Chemical action which causes destruction of the surface of a metal. Usually it is by oxidation. To diminish corrosion, paint, oil, and other substances are employed, or iron may be galvanised (*q.v.*) or treated by some process such as that of Barff. No process has yet been found which can prevent corrosion completely.

Corrosive Sublimate (*Chem.*) A common name for mercuric chloride. *See* MERCURY COMPOUNDS.

Corrugated Furnace Tubes (*Eng.*) Tubes with corrugations running right round the circumference. They are often used, as they present an increased heating surface, and also cause less strain in the main shell of the boiler, when they expand or contract, than straight tubes.

Corselet (*Armour*). A cuirass or piece of armour for covering the body, usually worn by pikemen, who were sometimes styled CORSELETS. Attached to the corselet in the case of footmen was armour for the thighs, called TASSETS.

Corsite (*Geol.*) A variety of diorite which shows a remarkable orbicular structure, due to an unusual disposition of its component minerals during its consolidation. It is sometimes called Napoleonite or Orbicular Diorite.

Cortile (*Architect.*) An interior court in a dwelling house.

Corundum (*Min.*) Native sesqui-oxide of aluminium, Al_2O_3. Aluminium = 53·4, oxygen = 46·6 per cent. It crystallises in hexagonal pyramids, and also occurs massive. Colour very varied. The massive form yields EMERY (*q.v.*) The finer coloured varieties yield many of the gems. *See* RUBY, SAPPHIRE, *and* AMETHYST (ORIENTAL). Found in East Indies, Piedmont, St. Gothard, Auvergne, New York, Burmah, etc. *Cf.* Carborundum.

Cos, Cosine. *See* TRIGONOMETRICAL RATIOS.

Cosec, Cosecant. *See* TRIGONOMETRICAL RATIOS.

Cost (*Her.*) *See* COTISE.

Costing (*Manufactures*). The determination of the cost of producing or distributing any given work.

Cost Sheet (*Manufactures*). A statement of the cost of production of given work. It should show the cost of labour, materials, general charges, depreciation of tools, etc., and each of these items may be further subdivided with advantage where several varieties of labour and materials are used in each piece of work.

Cot, Cotangent. *See* TRIGONOMETRICAL RATIOS.

Cothurnus (*Archæol.*) A Grecian hunting-boot laced up in front and reaching to the middle of the leg; also worn by tragic actors. *See* BUSKIN.

Cotise, Cottise (*Her.*) A diminutive of the bend, being one-half of the bendlet and one-fourth of the bend. When borne alone, it is termed a "Cost," but when borne in pairs, "Cotises."

Cotised (*Her.*) When an ordinary, such as a bend or fess, is bordered on both sides by a cotise, barrulet, etc.

Cottar (*Eng.*) A tapered pin or wedge used for tightening up and fixing parts of machinery.

Cottar Way (*Eng.*) A tapered slot through which a cottar passes. *See* COTTAR.

Cotton. *Gossypium* (various species; order, *Malvaceæ*). Three species of this plant yield the well-known material cotton, which is formed from the fibres covering the seeds. The seeds are used also in making cotton seed oil (*q.v.*) and oil cake. When woven into a fabric, cotton is durable, non-shrinkable, does not absorb moisture, and is a good conductor of heat. These features point to the conclusion that it should not be worn next the skin.

Cotton Manufacture. This industry may be divided into two distinct branches, *viz.* (1) Spinning; (2) Weaving. There are a few firms in England who carry on both industries, but it is the exception rather than the rule. On the Continent and in America the two are usually worked together under separate inside management. A firm who take both branches would be styled cotton spinners and manufacturers. It is the province of the spinner to convert by mechanical methods the fine short cotton fibres obtained from the cotton tree into a continuous uniformly twisted thread of unlimited length, the coarseness or fineness of which may be varied to suit the requirements of the trade. The manufacturer, in his turn, has to prepare the spun yarn so that when a number of threads are run together in parallel order in a convenient form in the loom woven cloth is produced. COTTON SPINNING: The primitive method of spinning was by means of the distaff (*q.v.*) and spindle, which gave place later to the domestic hand spinning wheel. In the year 1530 this was superseded for special purposes by the Saxony spinning wheel. This wheel both put the twist into the thread and wound it on a bobbin by means of a flyer. A very good spinner would be able to work a wheel containing two spinning spindles. An average number of spindles which at the present day may be attended to by a mule spinner and his two assistants is about two thousand. According to Dr. Ure, the earliest period that cotton is known to have been used in England as a textile staple was in the latter part of the fifteenth century. This industry, together with weaving, was carried on as a domestic occupation until the invention of Robert Kay's fly shuttle on the hand loom gave an impetus to the spinning industry, and was the means of bringing out in quick succession the inventions of Hargreaves, Arkwright, and Crompton. The advent of Arkwright's water frame, about 1769, was the means of gradually changing the whole system of domestic manufacture from the manual to the mechanical, and eventually establishing our present day factory system. The value of a cotton fibre for spinning purposes is determined by the following characteristics: length, fineness, uniformity in diameter and convolutions, cleanliness; the best and strongest spun yarns being those in which the greatest number of fibres in proportion to thickness of thread may be consolidated in a cross section. The following are the chief commercial staples of cotton used, given in order of importance and value: (1) Sea Island; (2) Egyptian; (3) Brazilian; (4) American; (5) Indian. The finest yarns are spun from Sea Island and Egyptian; the coarsest and low qualities from Indian cotton. The bulk of the cotton used for medium class yarns is American, and it is for this staple that there is the greatest demand. It may be mentioned here, that recently a cotton growing association has been formed in England among the spinners and manufacturers to experiment and eventually cultivate in some British possession a cotton fibre equal to, if not better than, the American, so that the control of the cotton market may be taken out of the range of speculators "who toil not, neither do they spin." The Germans are also adopting the same course in their African possessions. After the cotton lint or fibre is picked from the pod, it undergoes the process of "ginning" near to the cotton fields, and is then graded. It is afterwards packed by steam or hydraulic pressure in the form of an oblong bale, ready for transit to any part of the globe. In America the compressed rolled bale is very extensively used. It is in the bale form that the spinner receives it, and after being tested for weight, quality, and moisture, it undergoes the various stages of manipulation until a solid, approximately uniform, and cylindrically twisted thread is produced. The following is the order of processes that cotton would pass through in a modern English mill fitted up for spinning medium counts of yarns: (1) Bale breaker, (2) Mixing or Blending, (3) Open-

ing, (4) Scutching, (5) Carding, (6) Drawing (three heads), (7) Slubbing, (8) Intermediate slubbing, (9) Roving, (10) Spinning either by the ring frame or mule. When fine yarns of good quality are being spun it is necessary to introduce three other processes between the carder and drawing frame—*viz.* (*a*) Sliver lap machine, (*b*) Ribbon lap, (*c*) Combing; also, in many cases, an extra flyer frame, called a jack frame, would be used to follow the roving frame. Some spinners will sell the yarn for "twist" or "weft" direct from the spindle in the mule cop or ring bobbin; whilst others will have attached a reeling, warping, and doubling business. In the majority of cases, however, doubling is treated as another branch, along with gassing. When reeling and warping are attached there is a greater outlet for the sale of yarns, as, in addition to the cop and bobbin, it may be sold in the hank, balled warp, or chain lengths to suit the convenience of the manufacturer. The chief points of difference between the English and American systems of spinning may be summed up as follows: In England cotton is only carded once and drawn three times, and the majority of spinning spindles are on the mule, although a large number of rings are in use. In America they usually card the cotton twice and draw it twice, whilst their spinning machines are invariably ring frames, so that ring weft on a bobbin may be supplied direct to the weaver in addition to being used for warp. Reeling is practically unknown. A system of spinning is also in vogue, especially on the Continent, for respinning waste yarns into coarse counts, known as waste spinning. COTTON WEAVING: By weaving is meant the art of forming a cloth or fabric by the interlacing of strands or threads of various thicknesses one with another in order to form one broad sheet. Two distinct sets of threads, known as the warp and the weft, are used in the formation of the cloth. Early records point to the fact that in a simple way weaving was practised by the Egyptians, Chinese, Hindoos, and Greeks long before the art became known in England. It is said that we are indebted to the Romans for its introduction into this country, since on their invasion they commenced to weave woollen cloths for the use of their soldiers. The adoption of cotton as a textile staple was much later. *See* COTTON SPINNING. The inventions of Arkwright and Crompton in the spinning industry had the effect of giving a greater supply of yarn to the hand loom weaver than could be dealt with; hence there soon followed the invention of the power loom by Dr. Cartwright. His idea was to produce a machine that would be partially automatic in its action, and so, by enabling one person to attend to more than one loom at the same time, afford the means of dealing with the stock of yarn produced by the spinning spindles. The success of his invention revolutionised the weaving industry, and it may be said that our present day loom still retains, in the main, the chief features of Cartwright's invention. From this time onward the cotton industry continued to expand until it was found necessary to treat spinning and weaving as two separate branches of industry, as we find them to-day. The industry has also spread to such an extent on the Continent and in the United States of America—to a lesser degree in India, China, and Japan—that these countries make themselves felt as keen competitors, especially in our foreign trade. In order to produce cloth satisfactorily and economically, certain preparatory processes are necessary. These processes provide a warp beam containing warp threads in such number and length that any desired quality and width of cloth may be produced when in the loom. In present day manufacturing there are two main divisions—*viz.* (1) Grey Goods; (2) Coloured Goods. Each of these may be again split up into (*a*) Plain weaving; (*b*) Fancy weaving. A manufacturer of plain goods will produce fabrics of a simple or plain character, such as calicoes, twills, sateens, muslins, lawns, etc., known as "tappet" work. A fancy goods manufacturer will produce, in addition to the above, fabrics of a fancy weave character, comprising small figured or floral effects which require tact and skill in the arrangement of design. This necessitates the employment of more costly machinery in the form of dobbies or jacquards. The general English system of preparing grey and coloured warp threads for the loom are herewith given. GREY GOODS: The warp yarn is received in the twist cop, or ring bobbin, and undergoes the following processes: (1) Winding; (2) Beam warping; (3) Slashing and sizing; (4) Twisting or drawing in; (5) Weaving in the power loom, fitted up with either tappet, dobby, or jacquard. COLOURED GOODS: Two distinct systems of preparation are in vogue, each of which has its advantages, namely (A) Warping; (B) Yorkshire dressing. *System A:* The twist yarn is received in the grey hank state, and, after being bleached or dyed the required colours, undergoes the process of hank sizing, in addition to which the following processes are gone through: (1) Drum winding; (2) Warping; (3) Beaming or running on machine; (4) Drawing in or twisting; (5) Weaving as above. *System B:* The twist yarn, received in the form of balls or chains, is warp dyed and sized, and passed on to the dresser, who puts it through the process of Yorkshire dressing. From this stage the processes are as 4 and 5 in System A. The Scotch system of preparing coloured warps is mostly by the long chain or Scotch beaming process, which is similar to Yorkshire dressing, only that each colour is previously run on to a separate beam before all are run together on the weaver's beam in their pattern. The American system is similar to the Scotch, that is for coloured goods. The warps are made on a lease or chain warping machine, afterwards being dyed the required colours. The colours are then each run on to separate beams, only in their *unsized* condition. All the coloured ends from the beams are then run together on the weaver's beam in their correct pattern by means of the slasher sizer. Two size boxes are usually employed, one for white threads to run through, and the other for all colours. The American system for grey work is similar to the English.—H. B. H.

Cotton Blanket. *See* BLANKET.

Cotton Cords (*Eng.*) Ropes of cotton one-half to five-eighths of an inch in diameter, sometimes used for transmitting power in place of leather belts.

Cotton Covering (*Elect. Eng.*) Insulation consisting of one or more layers of fine cotton wound round wires in which high insulation is not necessary, *i.e.* where the voltage of the current in the wire is low.

Cotton Felt (*Paper Manufac.*) An endless cloth used for keeping paper in contact with heated cylinders during the operation of drying.

Cotton Gin. A machine used for separating the cotton lint from the seeds after picking from the pod. There are several kinds—the primitive Churka

gin, roller gin, saw gin. The two latter are mostly used, and of these there are several single and double acting patterns.

Cotton Seed Oil. Is obtained from the outer shells of the seeds of various kinds of the cotton tree, *Gossypium.* Until recent years these husks were deemed worthless, but now the cotton oil industry is an exceedingly large one, crushing of the seed being carried out in many places in England and abroad. The oil when expressed is of a ruby colour, and when refined pale yellow. It possesses a pleasant nutty flavour, and is very largely employed as a salad oil, for adulterating olive oil, butter, and lard, and in the manufacture of margarine. It is also used for pastry, fish frying, and in the manufacture of lubricating oils, soaps, and candles. When used as a food it is necessary to free it from stearin (*q.v.*) This is sometimes effected by merely allowing the oil to stand in storage tanks, and sometimes by chilling or by placing the oil in cylindrical bags of finely woven linen and allowing it to filter through, which it does slowly, leaving the stearin behind. Its specific gravity at 60° F. is 0·922 to 0·928.

Cotyledons (*Botany*). The temporary seed leaves of an embryo plant, functioning either as an absorbing organ or as storage places. There are two present in the seeds of dicotyledons, one in monocotyledons.

Cotyliscus (*Archæol.*) A small Greek vase with one handle, resembling the amphora in form.

Couch Roll (*Paper Manufac.*) A felt-covered roll used for squeezing out surplus water from the wet sheet of paper after it leaves a machine wire.

Coulisse, Cullis. The slides or grooves in which the side scenes run on the stage of a theatre. Applied also to a side scene itself and to the space between the side scenes.

Coulomb (*Elect.*) The quantity of electricity conveyed by a current of one ampère (*q.v.*) in one second.

Coulomb's Balance (*Elect.*) *See* TORSION BALANCE.

Coulomb's Law (*Elect.*) In electro-statics the force between two charges of electricity is proportional to their product, and inversely proportional to the square of their distance apart. In magnetism the force between two magnetic poles follows the same law.

Coumarin (*Chem.*) $C_6H_4\left\langle\begin{array}{l}^{(1)}CH : CH \\ \qquad\quad\ | \\ ^{(2)}O - CO\end{array}\right.$

A white crystalline solid with pleasant aromatic odour. Melts at 67°. Easily soluble in alcohol and hot water. Obtained by the action of acetic anhydride and sodium acetate on the aldehyde of salicylic acid. It occurs in Tonka beans, melilot, and woodruff. Used in perfumery.

Count (*Textile Manufac.*) *See* COUNTS.

Counter. (1) The curved part of a ship's stern. (2) That part of a horse that lies between the shoulders under the neck. (3) An imitation coin made of inferior metal. (4) A token.

Counterbalancing (*Eng.*) *See* BALANCING.

Counterbracing (*Eng.*) Strengthening a structure by means of tie rods running in opposite directions.

Counterchanged (*Her.*) When the field is parted per chevron or other ordinary, one half the field being metal and the other a colour, the tinctures of charges which fall upon the metal and colour are reversed.

Counter Cramp (*Carp. and Join.*) A cramp for drawing up and fixing the end-grain joints of strings (*q.v.*), counters, etc.

Counter Electromotive Force (*Elect. Eng.*) An E.M.F. in the armature of a motor while running, produced by its tendency to act as a dynamo, and thereby opposing the flow of the current which is being supplied to the motor. An ordinary continuous current motor takes less current as its speed rises, for the counter E.M.F. increases with the speed.

Counter Floor (*Carp. and Join.*) A foundation for laying a parquet floor on.

Counter Lath (*Carp., etc.*) Laths nailed across each other: similar to brandering (*q.v.*)

Countermark (*Archæol.*) The name given to impressions that are sometimes found on ancient coins and medals, and which have been effected subsequent to the first stamping of the coin. It is not certain why such marks have been made on ancient coins, but during the Peninsular War the British authorities were also in the habit of stamping Spanish dollars with a small countermark of the head of George III.

Counter Passant (*Her.*) Said of two beasts passing each other in opposite directions.

Counter Plate (*Engrav.*) Additions required to an engraving are made upon another plate and then printed off upon the original engraving. This second plate is called the counter plate.

Counterpoint (*Music*). The art of combining melodies. Contrapuntal study is divided into five species: (1) Note against note of the Canto Fermo. (2) Two notes against one of the Canto Fermo. (3) More than two notes against one of the Canto Fermo. (4) Syncopated. (5) Florid.

Counter Potent (*Her.*) One of the furs. The potents are arranged head to head, as in counter vair (*q.v.*) *See also* HERALDRY.

Counter Proof (*Engrav. and Print.*) A proof taken off another fresh-printed proof, the copy on the second proof being, of course, reversed.

Counter Shaft (*Eng.*) A subsidiary shaft driven from the main shaft, for transmitting and distributing power. It usually carries a coned pulley (*q.v.*) corresponding to a similar pulley on the machine which it drives.

Counter Sinking (*Eng., etc.*) Forming a recess at the top of a drilled hole to receive the head of a screw or rivet.

Counter Subject (*Music*). That part which accompanies the "Answer" in a fugue.

Counter Tenor (*Music*). *See* ALTO.

Counter Vair (*Her.*) One of the furs. The bells or cups are all of the same tincture, and placed base to base and point to point.

Countess Slate (*Build.*) A roofing slate 20 in. by 10 in.

Counting Glass (*Linen Manufac.*) Magnifying glasses made up in little frames having apertures of different sizes cut to standard gauges. When laid on a piece of linen, the number of threads appearing through the aperture are counted, and indicate the fineness of the cloth. These are also called "wet glasses" (*q.v.*)

Country Rock (*Mining*). The rock through which a vein runs.

Counts (*Cotton Spinning*). Refer to the diameter and weight of cotton yarns for a standard length. Single thread counts are denoted by the number of hanks of 840 yds. in 1 lb. (avoirdupois) or 7,000 grs. (Troy). Example: a 20 cotton thread = 20 hanks to 1 lb. ∴ 20 × 840 = 16,800 yds. to 1 lb. Folded-yarn counts are determined by the number of threads twisted together. Low coarse counts are denoted by yards per ounce.

—— (*Woollen Manufac.*) Applied to yarns as indicative of size or thickness and the number of yards in a given weight. Cotton counts are based on the number of hanks of 840 yds. in 1 lb.; Worsted, on the number of hanks of 560 yds. in 1 lb.; and Woollen on the number of skeins of 1 yd. in 1 dram.

Couped (*Her.*) Cut straight. When a charge, such as a head or leg of a man or beast, is cut off evenly and not erased.

Couple (*Mech.*) A system of two opposite equal parallel forces not in the same straight line. A couple can only produce a turning movement, not translation or movement from place to place.

Couple Close (*Carp.*) A roof having the lower ends of the rafters tied to prevent them from spreading.

Coupled Wheels (*Eng.*) Locomotive wheels connected by connecting or coupling rods. This ensures the distribution of the weight over two or more pairs of wheels, and increases the uniformity of running.

Couple, Electric. Any pair of substances, in contact or connected together, which can give rise to a difference of electrical potential, *e.g.* zinc coated with copper, or a plate of zinc and copper connected by a wire.

Couple Roof (*Carp.*) A roof having no tie at the lower end of the rafters. Cf. COUPLE CLOSE.

Couple, Thermo-Electric. Two metals which produce a difference of potential when heated at their junction.

Coupling (*Eng.*) (1) The appliance for connecting rolling stock on a railway. (2) In general, the connection of any two pieces of mechanism so that they operate together, *e.g.* shafts, wheels, engines, etc.

Coupling Lash *or* **Leish** (*Silk Manufac.*) The thread carrying lingoe (*q.v.*) and attached to mail, and carried from mail to necking cord, in figured harness.

Coupling of Dynamos (*Elect. Eng.*) Running two (or more) machines to supply the same circuit simultaneously.

Couplings (*Cotton Weaving*). An attachment to a Jacquard harness. It is suspended from the neck cords, and consists of sleeper cord, mail, and lingoe. One coupling is required for each separate warp thread in the width of cloth.

Course (*Build.*) (1) One layer of bricks or stones of the same height. (2) The vertical distance between two horizontal joints.

Coursed Rubble (*Build.*) Rough stones squared and built in courses varying in height.

Couteau de Chasse. A hunting knife of the sixteenth and seventeenth centuries. The sheath contained also smaller knives and other implements useful to the hunter.

Cove (*Plast., etc.*) A hollow curved moulding.

Coved Ceiling (*Plast., etc.*) A ceiling having a large hollow cornice.

Cover (*Cotton Weaving*). A term used to indicate that the warp threads are spread in the cloth width at equal distances, so as to destroy any raw or naked appearance which may arise by the threads passing in pairs or more through the splits in reed (*q.v.*)

Cover Chief (*Cost.*) A headdress resembling a nun's veil. In common use during the Middle Ages.

Covering Power of Pigments (*Dec.*) Often confused with the term "body" (*q.v.*) It refers to the extent of surface a pigment will cover, or the superficial area over which it will spread when thinned to a consistency suitable for being applied with a brush. The surface in square feet covered by 10 lb. of the following materials applied evenly to wood is, according to Hurst: Red lead, 113; white lead, 221; zinc oxide, 378; red oxide, 453; chrome yellow, 252; Brunswick green, 310; lampblack, 382; ultramarine, 462.

Cover Stones (*Build.*) Flat stones laid on the top of girders, etc., as a foundation for the wall above.

Cow Hair. Is mixed with plaster, foundry loam, etc., to ensure cohesion or porosity.

Cowls (*Hygiene*). Used for the purpose of aiding ventilation of buildings. They are fixed on outlet ventilating shafts, and are said to increase the exhausting action which the wind exerts when passing over the tops of these shafts. They prevent down-draughts, and also prevent the entrance of rain. The disadvantage of cowls is the uncertainty of their action.

Cowper Stove (*Met.*) A Regenerative Stove (*q.v.*) for heating the blast by the combustion of the furnace gases.

Cowrie, Cowry. *Cypræa moneta* (class, *Gastropoda*). A small shell found in Eastern seas and used as money in Africa and East Indies.

Cowrie Pine, Kauri Pine. *See* TIMBERS.

Cow's Milk (*Foods, Hygiene*). The quality and quantity varies with the age, breed, food, and condition of the cow. Milk is a perfect food, containing all the proximate alimentary principles—*i.e.* proteids, fats, carbohydrates, salts, etc.—necessary for the sustenance and development of a child. It is therefore of the highest importance that it should be supplied pure and unadulterated. That this is not so is well known. Water is the chief adulterant; but cane sugar, glycerine, carbonate of soda, boric acid, formalin, etc., and annatto, for colouring are also added. Milk plays a very important part in the cause and spread of many of the infectious diseases. Great care should be taken that milk is not placed where it will be liable to contamination, as it readily absorbs gases and vapours, and, moreover, affords a good breeding ground for the growth and multiplication of micro-organisms

Coypu. *Myopotamus coypu* (family, *Octodontidæ*). A South American rodent of beaver-like habit. The under-fur, which is imported in large quantities, is known as PUTRIA or RACOONDA.

Cr. (*Chem.*) Symbol for CHROMIUM (*q.v.*)

Crab. A windlass or winding mechanism similar to that of a crane. It includes a barrel on which the chain or rope is wound, and a winch or crank handle whose shaft is usually connected to the barrel by toothed gearing. The term is also applied to a similar machine driven by power.

Crabbing (*Woollen Manufac.*) A compound process of boiling and blowing pieces of cloth with steam while lightly wound on a perforated roller, to prevent subsequent wrinkling of the cloth, etc.

Cracking of Varnish (*Dec.*) This fault in a varnished surface is sometimes caused by applying the varnish over a coat of paint that has not dried hard; or by applying a coat of hard varnish over an elastic varnish. If the fault arise from the varnish itself, it is usually due to an excess of drying material being used in the manufacture.

Crackle (*Pot.*) A species of pottery, the glazed surface of which is crazed or cracked in the firing process. Japanese pottery of this description is highly valued.

Cracowes (*Cost.*) Shoes with long pointed toes. First worn in the fourteenth century at Cracow in Poland. In England it was necessary to pass a law regulating their length.

Cradle (*Dec.*) A movable scaffold consisting of a platform railed in on two sides and suspended by ropes by which it is raised or lowered. Used by painters and builders when ladders cannot be conveniently employed. The loose ends of the ropes are held by men on the ground, but in some patented patterns the cradle may be operated by those who are in it.

—— (*Eng.*) A name often used in mechanism for a support or system of supports, especially for those carrying an object which can be easily lifted out and replaced.

—— (*Lace Manufac.*) In a lace machine, a curve concentric with the centre of an oscillating movement, and forming a "bed," which gives support and prevents or minimises vibration.

—— (*Mining.*) A rocking frame for washing ores.

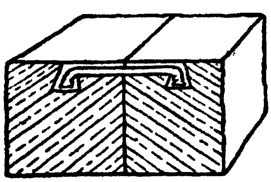
Cradling (*Carp. and Join.*) (1) The rough bracketing round a girder to which the lathing is nailed. (2) An arrangement for glueing up treads and risers (*q.v.*) in making a staircase.

Crag (*Geol.*) A name for a geological formation (as distinguished from a geographical feature). This term is applied to certain shelly sands and gravels which were formed during Pleiocene times, chiefly in East Anglia. Thus there is the CORALLINE CRAG (so called from the abundance of polyzoa, not of corals, which it contains), the RED CRAG, NORWICH CRAG, etc.

Cragleith Stone. *See* BUILDING STONES.

Cramming (*Plumb.*) To plug up a pipe with bread, etc., while a joint is being made.

Cramp (*Build.*) A bar of iron with the ends bent at right angles; used for fixing stones together.



CRAMP.

—— (*Join., etc.*) A tool made in a great variety of forms, by means of which sustained pressure can be applied to a piece of work; *e.g.* cramps are used to hold glued joints together while the glue is setting. The pressure is usually applied by means of a screw.

Cramponné (*Her.*) A charge is cramponné when its termination is in the form of a cramp: an iron used in building, having each end bent. *See* CRAMP.

Crampoon (*Build.*) A clutch for holding blocks of stone or balks of timber when they are required to be raised by means of a crane.

Crancelin (*Her.*) A coronet extended in bend; also blazoned a bend treflée vert. It is borne in the arms of Saxony.

Crane. A crane is a piece of machinery used for raising heavy weights to some distance above the level of the ground. In the simplest form the crane consists of a roller or drum, round which a chain is wound, and which is turned either by hand or by power. The chain passes over a pulley wheel, fixed on the end of a long beam called the jib. The jib is usually hinged at its lower end to the frame of the machine, from which it projects at an angle, and this angle can in many cases be altered. In order to keep the jib at its proper angle, either tie rods or chains are fixed to it. These tie rods or chains are brought down and fixed to some part of the frame or baseplate. If the chains are so arranged that they can be lengthened or shortened, the angle of the jib can be easily adjusted. A crane whose jib can be adjusted in this way is termed a DERRICK. The whole frame is usually carried on a vertical axis or crane-post, so that the crane can turn through a considerable angle or even make a complete revolution. This pivot is fixed in the base or foundation in the case of stationary cranes, and in the case of portable cranes to a very strong carriage, which runs on rails. A crane of this type usually has the following separate motions: (1) The ordinary hauling action of the crane, by which the load is raised or lowered. (2) A derricking motion, by which the jib can be fixed at any convenient angle, thus altering the area over which the crane can work, and enabling the load to be moved or "swung" nearer to or farther from the crane after it is raised. (3) A rotary motion about the vertical axis of the crane, enabling the load to be swung round through any part of a circle. (4) A travelling motion whereby the crane can run along its line of rails. All these motions can be obtained from the action of the engine which drives the crane, and which is mounted on the framework of the crane itself. To counteract the tendency of such a crane to overturn, some heavy weight is fixed on part of the frame opposite to the point at which the jib is fixed. This weight may be any heavy mass of convenient size, or in the case of steam cranes it may consist of the engine and boiler themselves. These arrangements constitute what is called a BALANCE CRANE. In many cases the power of the crane is supplied by a hydraulic engine or an electric motor; the former is chiefly suited to the working of stationary cranes. The jib is sometimes dispensed with, and the hauling mechanism is then fixed on beams overhead, so that it can run along in either of two given directions. Such a crane is called a TRAVELLER, or TRAVELLING CRANE, and is used in engineering shops. Large girders are fixed along two longer walls of the shop, and a frame consisting of a couple of girders equal to the distance between these two longer girders can be moved along the latter on wheels. A crab or hauling mechanism is then mounted on two shorter girders, so that it can run along them when required. The power is very commonly transmitted to a traveller from a fixed engine or motor placed on the floor of the shop, but the most convenient arrangement is to have an electric motor contained in the crane itself, as the current can easily be conveyed to it. For harbour works, etc., some form of traveller is frequently used, running on rails, as a jib crane is

scarcely strong enough to deal with the enormous weights which have to be moved. A GOLIATH CRANE is a traveller in which the cross girders are mounted on standards which are provided with wheels at their bases, so that the whole structure can run along on rails laid down for the purpose. A HERCULES CRANE is a travelling crane with a horizontal jib. An ACCIDENT CRANE is a portable crane mounted on a railway truck.

Crane Post (*Eng.*) The vertical pillar in a crane. To the top are attached the tie rods supporting the jib; the bottom is fixed to the base plate of the crane.

Crank (*Eng.*) A lever keyed at right angles to a shaft or made solid with it, by means of which the shaft is turned, or imparts motion. When the shaft is of small diameter, it is often bent, in order to form the crank, as in the case of the crank shaft of a foot lathe. There are several forms, single-, double-, disc-cranks, etc.

Crank Axle (*Cycles*). The spindle to which the two cranks and the driving chain wheel are fastened; it runs in ball bearings in the bottom bracket. *See also* CYCLES.

Cranking (*Eng.*) (1) Bending in some special manner. (2) The curving or hollowing out of a cutting tool behind the cutting point or edge in order to allow a certain amount of spring in the tool.

Crank Pin (*Eng.*) The cylindrical stud or pin of a crank, to which the connecting rod is attached.

Crape. A material of light texture, with a crimped surface, made of handspun silk yarn in the natural state. On adding to the texture a quantity of gummy matter in finishing, the threads "creep" or crimp. Crapes are also made of worsted yarns, the effect being obtained by passing the pieces between engraved rollers.

Crash (*Dec.*) *See* CANVAS WALL COVERINGS.

Crater (*Geol.*) A term generally restricted to the funnel-shaped cavity which forms the mouth, or uppermost part, of a volcanic vent.

—— (*Pot.*) A large vase or cup with two handles, and having a wide, open mouth. It was used by the Greeks and Romans for mixing wine and water.

Crawling (*Dec.*) A defect in varnished work which sometimes takes place when there is a sudden change in temperature while the varnish is drying, particularly when the coat of varnish is too thick. The defect cannot be remedied, and the only cure is to remove the varnish and do the work again.

Crayon (*Art*). A kind of pencil for drawing, made of chalk mixed with other materials, black, white, or coloured.

Craze (*Pot.*) When the glaze on the surface of pottery is cracked it is said to be CRAZED. Caused by accident in the process of firing.

Creak (*Met.*) The cracking sound made by metallic tin when bent. Sometimes termed CRY. The sound is due to the rubbing together of the crystalline particles of the metal.

Cream Laid. Writing paper with a ribbed surface, of a cream colour.

Cream of Tartar (*Chem.*) A common name for acid potassium tartrate. *See* TARTRATES.

Cream Wove. Hand-made writing paper, having a smooth surface and of a cream colour.

Creasing Course (*Build.*) A course of tiles (near the top of a wall) projecting on each side to throw off the rain, and to prevent the water from soaking down the wall: a damp-proof course at the top of a wall.

Creatine, Methyl Guanidine Acetic Acid,

$$HN : C \begin{cases} NH_2 \\ N\,.\,CH_3\,.\,CH_2\,.\,COOH \end{cases} .$$

White prisms containing 1 molecule H_2O: soluble in water. It occurs in muscle, especially in the juice. Can be made artificially from sarcosine (methyl glycocoll) and cyanamide, $CN\,.\,NH_2$. It is present in all meat extracts. Acids, on digestion, convert it into creatinine, the same change occurring on evaporating its solution. Baryta water changes it to urea and sarcosine.

Creatinine (*Chem.*), $HN : C \begin{cases} NH\text{———} \\ N\,.\,CH_3\,.\,CH_2\,.\,CO \end{cases} .$

White prisms: soluble in water: strong base giving salts with acids. Forms a highly characteristic compound with zinc chloride $(C_4H_7N_3O)_2ZnCl_2$, which is very sparingly soluble in water and whose formation serves as a means of separating creatinine from its solutions, *e.g.* from urine, of which it is a normal constituent. Creatinine reduces Fehling's solution (*q.v.*), and normal urine owes its slight reducing power to this substance. It is formed from creatine (*q.v.*), and is reconverted into this on boiling with alkalis.

Credentia *or* **Credence.** A kind of small sideboard with one or more shelves. In churches the credence table is used to hold the sacred vessels before they are placed upon the altar.

Creel (*Cotton Spinning*). A stand to hold a number of bobbins either on a flyer frame, ring frame, mule or warping machine. There are three kinds: (1) straight, (2) circular, (3), V-shaped.

Creep (*Mining*). The movement or bulging of the floor of a mine through the pressure of the rocks around.

Creeping (*Eng., etc.*) The slight slip which occurs between a belt and the wheel or drum over which it runs. Also a general term for a slow movement of one part of a structure relative to another part which is in contact with it.

—— (*Chem., etc.*) The tendency of certain solutions of salts to ascend the sides of their containing vessels, and leave a solid deposit (*e.g.* sal-ammoniac solution).

Creeping of Tyres (*Cycles, Motors*). A tendency for a tyre to rotate relatively to the rim. Creeping not only loosens the tyre, but also tends to produce leakage through the strain set up at the valve.

Cremation (*Hygiene*). The cremation of human remains is regulated by the Cremation Act, 1902. Burial authorities under this Act are empowered to provide and maintain CREMATORIA, which must not be constructed within a specified distance of a dwelling house or public highway, and are subjected to regulations prescribed by the Secretary of State. This hygienic disposal of human remains is in operation at Woking, Liverpool, Manchester, Hendon, etc.

Cremnitz White *or* **Vienna White** (*Paint.*) A pigment composed of pure white lead.

Cremona *or* **Cremonese.** A name given to violins made at Cremona, a town in Lombardy, in the seventeenth century by the Amati family, and in the early eighteenth century by Stradivarius. These instruments have never been excelled, and command very high prices.

Creosote (*Chem.*) A liquid obtained from either wood tar or coal tar. That from wood tar is derived from the fraction, heavier than water, obtained on distilling the tar. This is treated with alkali, and the solution produced is separated and precipitated with acid, then distilled. The fraction which distils at 200° to 220° is creosote. It is a mixture of phenol, cresol, and the methyl ethers dihydric and trihydric phenols with other substances. Coal tar creosote is that fraction of coal tar which distils between 230° and 270°. It contains phenol, cresol, napthalene, anthracene, and many other substances. Wood creosote is colourless: coal creosote is greenish and fluorescent. Creosote is used in preserving timber and as a disinfectant. Creosote is not soluble in water, and to make it so for use as a disinfectant (*e.g.* Jeyes'), resin and caustic soda are added to it.

Creosoting (*Eng.*, *etc.*) The impregnation of timber by first drying in a vacuum and then soaking in CREOSOTE (*q.v.*) under pressure. The durability is very greatly increased by this process, especially in the case of timber which is to be exposed to the open air or to be partly underground (*e.g.* railway sleepers).

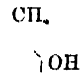
Crepon. A dress fabric, the surface of which is cockled, composed of a shrinkable and an unshrinkable yarn.

Crequier (*Her.*) A French charge, representing a chandelier of seven branches.

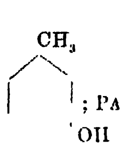
Crescendo (*Music*). Increasing in loudness. Abbreviation, *Cres.*, or $<$.

Crescent (*Her.*) A charge in the form of a half moon. Also used as a mark of difference on a label, to distinguish the second son.

Cresols (*Chem.*), $C_6H_4\left\langle\begin{matrix}CH_3\\OH\end{matrix}\right.$. There are three of



these compounds, *viz.* ORTHOCRESOL,

METACRESOL, 

; PARACRESOL, 

. The first melts at 31°, the second at 4°, and the third at 36°. O-cresol gives a blue colour with ferric chloride. They all occur in wood tar and coal tar. They are obtained from the corresponding toluidines (*q.v.*) by means of the diazo reaction. Like phenol they have a disagreeable smell, are antiseptics, but less poisonous than phenol. They are not oxidised by chromic acid. P-cresol is a product of the putrefaction of albumin.

Crest (*Her.*) An adjunct to the shield, represented on a wreath, coronet, or chapeau, and placed above the helmet in an achievement. In ancient times worn on the helmet as a distinctive mark.

Cresting (*Architect.*) An enriched finishing surmounting any feature of a building. It is also known as BRATTISHING. A crest much used in Perpendicular Gothic work is known as the TUDOR FLOWER (*q.v.*)

Cresylic Acid (*Chem.*) A name given to the uncrystallisable liquid obtained in the manufacture of phenol: it is chiefly a mixture of the cresols.

Cretaceous System (*Geol.*) The uppermost member of the Secondary Rocks. It is so called because a conspicuous member of the system is the Chalk (Latin, *creta*). The system includes the Upper Greensand and the Gault, which, with the Chalk, form the Upper Cretaceous rocks of those geologists who regard the Lower Greensand as an inferior member of the Cretaceous System.

Crib (*Mining*). A hollow cage-like structure of timbering. It may be left empty, as when it lines any cavity, or be filled with rock, etc., to form a support for the roof or other part of the workings.

Cribwork (*Civil Eng.*) Framing of piles or other timbered work, sometimes filled up with concrete or masonry. Used for carrying the foundations of submarine work.

Crimp Cloth (*Cotton Manufac.*) A form of cotton weaving in which longitudinal sections of the cloth are uniformly crimped or crinkled purposely. This is caused by weaving warps at different tensions.

Crimson Lake (*Dec.*) A bright red pigment prepared in a somewhat similar manner to carmine (*q.v.*) It is not permanent, and is used by decorators principally as a glazing colour (*q.v.*)

Crinoidal Limestone (*Geol.*) Calcareous rocks of marine origin, which largely consist of the disjointed fragments of the stems of Encrinites. Good examples are presented by some varieties of the Carboniferous Limestone.

Criophorus. Literally "one who carries a ram." Hermes was so named for having saved the people of Tanagra from the plague by carrying a ram round the walls.

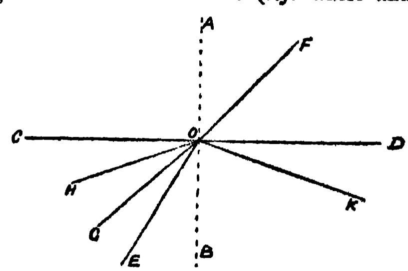
Crio Sphinx. A sphinx with the head of a ram. One of the three varieties of the Egyptian Sphinx, the others being the "Andro Sphinx," with the head of a human being, and the "Hieraco Sphinx," with a hawk's head. *See* SPHINX.

Crisis (*Glass Manufac.*) The period at which the heat of the furnace, after materials are thoroughly fused, is reduced to the temperature required for working the metal.

Crispine (*Cost.*) A headdress similar to the ancient calantica (*q.v.*)

Critic (*Art*). A person who examines works of art critically and pronounces opinion upon their merit or value. Properly an expert who has knowledge of the subject criticised.

Critical Angle (*Light*). Let CD be a surface separating two transparent media, the lower one being the denser of the two (*e.g.* water and air).



Then if a ray EO strike the surface, it will be bent away from the normal AOB, along a line OF, in

accordance with the law of refraction, sin AOF = μ sin EOB. If now the angle EOB be increased, AOF will go on increasing until sin AOF = 1, and the refracted ray passes along OD. When this is the case, the ray in the dense medium makes an angle BOG with the normal, such that

$$\mu \sin \text{BOG} = 1$$
$$\sin \text{BOG} = \frac{1}{\mu}$$

This angle BOG is termed the CRITICAL ANGLE. If a ray make an angle with the normal greater than the critical angle, as at HO, then it suffers TOTAL INTERNAL REFLECTION along a line OK, and does not emerge into the upper medium at all. *See also* ERECTING PRISM.

Critical Pressure (*Phys.*) The vapour pressure of a liquid which is at its critical temperature (*q.v.*)

Critical State (*Phys.*) The condition of a substance which is at its critical temperature and pressure. In this state the liquid and gaseous forms of matter merge into one, a very slight rise of temperature making the substance gaseous, and a very slight reduction of temperature causing partial condensation to a liquid; also in this state both liquid and vapour have the same density, and the latent heat of vaporisation disappears.

Critical Temperature (*Phys.*) The temperature, above which it is not possible to liquefy a gas by the application of pressure, however great: in other words, the temperature above which the substance is absolutely incapable of existing in the liquid state.

Critical Volume (*Phys.*) The specific volume, *i.e.* the volume of unit mass of a substance when at its critical temperature (*q.v.*)

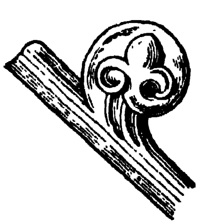
Crizzling (*Glass Manufac.*) Damage caused on the surface of glass by using cold tools whilst it is being manufactured.

Croccin Scarlet. *See* DYES AND DYEING.

Crocidolite (*Min.*) A pseudomorph (*q.v.*), in quartz, of a variety of hornblende (*q.v.*) with a fibrous structure; it has a blue colour, owing to the presence of ferrous oxide; by the change of the latter to ferric oxide the mineral becomes golden yellow. It is used as an ornamental stone. Sometimes termed BLUE ASBESTOS.

Crock (*Pot.*) Utensils of clay of any form are called crocks. Crockery is derived from this term.

Crocket (*Architect.*) A hook-shaped Gothic ornament usually consisting of half-opened leaves. It is used in series on the angles of spires, pinnacles, etc., and on dripstones to doors and windows. The earliest, and perhaps the finest, examples are found in the later part of the Early English period.



CROCKET.
EARLY ENGLISH.
SALISBURY CATHEDRAL.

Crocodile Shears and Squeezer. (*Met., Eng.*) *See* ALLIGATOR SHEARS, *etc.*

Crocoisite (*Min.*) Chromate of lead, $PbCrO_4$. Lead oxide = 68·9, chromic acid = 31·1 per cent. It occurs in reddish-yellow crystals of the Monosymmetric System. It is now a rare mineral. From Siberia, Hungary, and the Philippine Islands.

Cromlech (*Architect., etc.*) *See* PREHISTORIC ARCHITECTURE.

Crop Hides (*Leather*). Well grown heifer or ox hides tanned whole with oak bark, chiefly used by country cobblers. They have been largely superseded by BUTTS and BENDS.

Cropped (*Bind.*) Said of a book that has had its margin cut down too much.

Croppie (*Glass Manufac.*) An iron instrument used for conveying a cylinder of glass to the flattening stone. *See* SHEET GLASS *and* GLASS MANUFACTURE.

Cropping (*Eng., Met., etc.*) Cutting the ends of bars, rails, etc.; especially cutting iron bars into lengths suitable for making into a fagot (*q.v.*)

—— (*Woollen Manufac.*) Relates to the removal or shortening of the nap, pile, or fibre on the face of the fabric, by cutting. The work is done on the cropping or cutting machine.

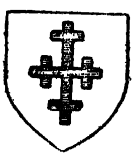
Crore. Ten millions = one hundred lakhs.

Crosier. *See* CROZIER.

Cross (*Eng.*) A name applied to various objects whose form is that of a cross; *e.g.* a four-armed support used in foundries for raising heavy weights: a connecting piece for four pipes or rods which meet at right angles, etc.

—— (*Her.*) This is one of the ordinaries; it is formed from two other ordinaries—the pale and the fess. If not otherwise determined, the cross is placed in the centre of the field, and extends till it meets the outer edges of the shield. The cross exists in many forms. Gwillim enumerates 39 varieties; Leigh, 46; Edmondson, 109; and Robson, 222. The following are among the principal varieties:—*Anchored:* With the limbs terminated in anchors. *Avellane:* With filbert husks at the ends of the limbs. *Botonée* or *Treflée:* Has trefoils at the ends of the limbs. *Botonée Fitchée:* The same as botonée, but with the lower limb pointed. *Calvary:* A Latin cross on steps or on degrees. *Cercelée* or *Recercelée:* The ends of the limbs are floriated. *Champain* or *Pointed:* The ends of the limbs are pointed. *Clechée* or *Urdée:* With a blunt arrowhead at the end of each limb *Couped* or *Humettée:* When the end of each limb is cut off square, so that it does not reach the edge of the shield. *Crosslet:* With each limb crossed. *Crusilly* or *Crusilé:* Several cross crosslets on a field. *Degraded:* A Latin cross on steps (usually three). *Engrailed:* The lines of the cross engrailed. *False:* *See* Voided. *Fimbriated:* With a narrow border to each limb. *Fitchée:* With the lower limb pointed. *Flourie:* With the end of each limb formed into a fleur-de-lis. *Fleurettée:* With a fleur-de-lis attached to the end of each limb and not forming a part of it, as in the last. *Formée:* *See* Patée. *Fourchée:* A cross moline with the curved ends of the fers-de-moline cut off. *Fylfot:* A cross Cramponné. *See* FYLFOT. *Greek:* With limbs of equal length. *Humettée:* *See* Couped. *In Cross:* When charges are arranged crosswise. *Latin:* With the point of intersection placed above the centre of the shield, and the three upper limbs of the same length, but the fourth much longer. *Maltese,* or *Cross of Eight Points:* A variety of cross patée in which the wide extremities of the limbs are

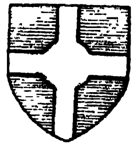
CLECHÉE.



CROSSLET.

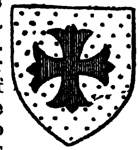
LATIN.

notched or indented. This was used by the Knights Templars and Hospitallers. *Moline:* With the terminations of the limbs formed of fers-de-moline or mill-rinds. *Nowy:* At the centre is a rounded disc which shows between the intersecting limbs. *On Degrees:* *See* Calvary. *Passion:* A Latin cross couped. *Patée* or *Formée:* The limbs are wedge shaped, with the apex at the intersection; they are of equal length, and do not reach the edges of the shield. *Patée Fitchée:* A cross patée with the lower limb pointed.



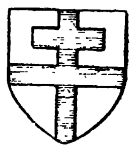
NOWY

Patonce: The limbs are not drawn with parallel lines, but gradually tapering to the intersection; the ends are floriated. *Patriarchal:* A cross with the upper limb crossed by a bar shorter than the central limb. *Pointed:* *See* Champain. *Pommée* or *Pommelée:* With a ball at the end of each limb. *Potent:* With a bar at the end of the limb at right angles to the limb, and of the same length as the limb, called after the fur of that name.



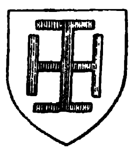
PATONCE.

Potent Fitchée: A cross potent with lower limb pointed. *Potent Quadrate:* A cross potent with intersection as in Quadrate. *Quadrate:* When the centre is square, not round. *Quarter Pierced:* A small square hole at the intersection of the limbs. *Quarterly Pierced:* The whole of the intersection is removed, the limbs only touching and not crossing. *Ragulée:* When the limbs are bounded by lines ragulé. *Rayonnant:* With rays of light springing from the intersection of the limbs.



PATRIARCHAL.

Recercelée: *See* Cercelée. *Saltire*, or *Cross of St. Andrew:* Formed by the intersection of a bend with a bend sinister, similar to a capital X, known as the Cross of St. Andrew; it extends to the edges of the shield. *Tau* or *Cross of St. Anthony:* Has no upper limb; it resembles a T, the Greek equivalent being Tau. *Treflée:* *See* Botonée. *Undée:* With the border lines undé. *Urdée:* *See* Clechée. *Voided* or *False:* When the entire centre of the limbs is cut out, only the outline being shown.



POTENT.

Voided throughout: When the voiding is carried to the ends of the limbs of the cross. *Wavy:* With the border lines wavy. NATIONAL CROSSES:—*England:* Cross of St. George: A red cross on a white ground. *Scotland:* Cross of St. Andrew: A diagonal white cross on a blue ground. *Ireland:* Cross of St. Patrick: A diagonal red cross on a white ground.

Cross, Archiepiscopal. *See under* CROZIER.

Cross Band (*Woollen Manufac.*) Applied to yarns, and meaning that the twine in spinning has been inserted from right to left. *See* OPEN BAND.

—— (*Lace Manufac.*) Breadths of lace made crosswise of the lace machine. Good effects may be obtained by this method, but the length of each breadth is limited to and determined by the width of the machine.

Crossbow (*Arms*). A missive weapon consisting of a bow fixed to a grooved stock or barrel which held the missile, and a mechanism for bending the bow, some of the largest being furnished with a windlass for this purpose. It was the favourite weapon of the Genoese, and was also used by the Swiss, the French, the Germans, and the Chinese. In England it was superseded at an early period by the handier and more deadly longbow, which could be fired four times as quickly. The missile generally used with the crossbow was the square-headed bolt or quarrell.

Cross Bred (*Woollen Manufac.*) A term applied to medium-stapled wools, and indicative of the crossing of fine and medium wool sheep, etc.

Cross Course (*Mining*). A vein running into or out of another one at an angle.

Cross Cut Chisel (*Eng.*) A narrow cold chisel. *See* COLD CHISEL.

Cross Cut File (*Eng.*) *See* DOUBLE CUT FILE.

Crossed Arm Governor (*Eng.*) *See* GOVERNORS.

Crossed Lens (*Light*). A biconvex lens in which the curvatures of the two surfaces are unequal. This construction can be made to give less spherical aberration (*q.v.*) than that produced by a biconvex lens whose surfaces have the same curvature.

Cross Girders (*Eng.*) Short bars or girders acting as side struts or ties between two longer girders.

Cross Hatching. Engraving or hatching a surface with series of parallel lines, one series crossing the other. In drawings and engravings shading is effected by this method.

Cross Head (*Eng.*) The structure fixed to the end of a piston rod to which the connecting rod and the slide blocks (*q.v.*) are attached; also a bar, plate, etc., fixed to the end of the plunger of a hydraulic press or ram.

Cross Heading (*Mining*). A drift or passage from one level to another for ventilating purposes.

Crossings (*Eng.*) Spaces left in the rails when one set of lines crosses another on a railway; they allow the flanges on the wheels to pass through when a train is running on a set of rails which crosses another set at an angle.

Cross Magnetisation (*Elect. Eng.*) The production of magnetic lines in the armature of a dynamo or motor, due to the current flowing through its own coils; inside the iron of the armature these lines are approximately at right angles to the lines sent through the armature by the field magnets. The effective field in the air gap acting on the armature conductors is the resultant of the cross field and the original field, and is equivalent to a rotation of the original field in the direction of motion in the case of a dynamo, and in the opposite direction in the case of a motor. If there be a lead to the brushes, a demagnetising effect will also be produced.

Cross, Monumental. The eleventh century saw the commencement of the use of these on gravestones, sometimes incised, sometimes in low relief. Examples are still extant of the plain linear cross, but more often it was adorned with floriated ornamentations on the upper limbs, and the elongated shaft was generally enriched. When monumental brasses were introduced, some bore the cross, either plain or sometimes showing elaborate enrichments, with or without figures kneeling at the base or within the opened out heads or at the intersection of the upper limbs of the cross. *Initial Crosses* are to be found at the beginning of monumental inscriptions: a plain Greek cross was generally used.

Cross, Pectoral. A cross worn on the breast by high ecclesiastics and royal personages. Notable examples: St. Cuthbert's Cross at Durham, Dagmar Cross in Denmark.

Cross Section. (1) A cut across any object at right angles to its length or to some other specified line. (2) A drawing of such a section.

Cross Slide (*Eng.*) The part of a planing machine which carries the tool box, and along which the latter can be moved in a direction at right angles to the traverse of the table of the machine.

Cross Tongue (*Carp. and Join.*) A thin slip of wood with the grain at right angles to its length. It is used to form the tongue in a tongued and grooved joint when extra strength is required.

Cross Tubes (*Eng.*) This term is usually applied to tubes running horizontally through the firebox of a vertical boiler. *See* BOILERS.

Cross Wind (*Woollen Manufac.*) A method of winding the yarn on to a bobbin, with a short cross traverse.

Crotal (*Archæol.*) An ancient rattle, or castinets made of bone or wood. Used perhaps as an accompaniment to dancing.

Crotchet (*Music*). *See* NOTES.

Croton Compounds (*Chem.*) CROTONIC ALDEHYDE, $CH_3CH : CH . CHO$, a liquid with irritating odour and boiling at 104°, is obtained by the condensation of aldehyde on heating with zinc chloride. On careful oxidation it yields CROTONIC ACID, an acid capable of existing in two stereoisomeric forms. *See* STEREOISOMERISM.

$$\begin{array}{c} CH_3 . CH \\ \| \\ HC . COOH \end{array} \qquad \begin{array}{c} CH_3 . C . H \\ | \\ HOOC . C . H \end{array}$$

The ordinary form melts at 72°.

Croton Oil. A powerful irritant drug obtained from the seeds of *Croton Tiglium* (order, *Euphorbiaceæ*) by pressure. The plant is a native of the East Indies.

Crowbar. A long bar of iron with a claw at one end. Sometimes the end is flattened or chisel-like, without being formed into a claw. Used as a wedge or lever for a variety of purposes.

Crown. Originally a crown was a wreath composed of flowers, or leaves of laurel, oak, olive, etc. Such crowns were awarded by the Greeks and Romans to victors in public games and to citizens who had greatly benefited the State. Eventually such crowns were made of gold. In modern times the crown is the badge of sovereignty, and forms the covering for the head of a monarch on State occasions. The English crown consists of a cincture of gold adorned with precious stones, and having alternately four Maltese crosses and four fleurs-de-lis. From the crosses spring arches, surmounted at the point of intersection by a mound and cross. The crown so formed encloses a crimson velvet cap having an ermine border. Coronets (*q.v.*) are without the arches. The crown of Charlemagne, which is still preserved in Vienna, is composed of eight plates of gold varying alternately in size and connected by hinges, the larger plates being jewelled and the smaller ones ornamented with enamels. The front plate of this crown is surmounted by a cross.

THE ENGLISH ROYAL CROWN.

—— *Her.* The heraldic crown has various forms, and generally has one or more arches. The earlier form of crown differed only slightly from the coronet.

—— (*Build.*) The highest part of an arch. *See* ARCH.

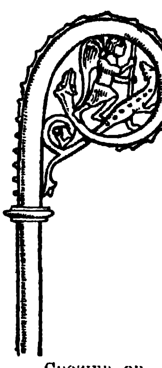
Crown Glass. This is now used principally for mosaic picture windows, the varying tints of the circles or sheets, due to its irregular thickness, being an advantage, and the necessity of flattening is avoided. It has a more brilliant surface than either sheet or plate glass, but owing to its method of manufacture the surface is not so regular, and the diameter (the sheet is circular) does not exceed 70 in. The bull's-eye in the centre further reduces, to a considerable extent, the size available for use. *See* GLASS MANUFACTURE.

Crown Leather. Known also as PRELLER'S LEATHER and HELVETIA. Made first, fifty years ago, by Preller, and stamped with a crown. The leather is prepared by drumming (*q.v.*) hides in mixture of oil, fat, flour, and salt. Used for belt laces and light belting.

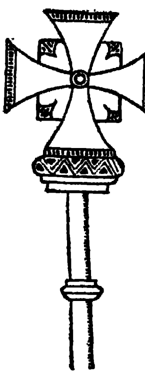
Crown Wheel (*Eng.*) A toothed wheel with the teeth at right angles to the plane of the wheel. Used in certain cases instead of bevel wheels for connecting two shafts at right angles.

Crow Step Gable (*Architect.*) *See* CORBIE STEP GABLE.

Crozier. The sign of office of a bishop or abbot. It is in the form of a shepherd's staff with a crooked end. The staff used by an archbishop is surmounted by a cross.



CROZIER, OR PASTORAL STAFF. THIRTEENTH CENTURY.



ARCHIEPISCOPAL CROSS.

Crucible (*Metallurgy*). A pot in which melting operations are carried on. Made of some form of porcelain, fire-clay, magnesia, plumbago, graphite, lime, or a special refractory mixture. A good crucible should withstand the highest temperature to which it is liable to be subjected, without fusion. It should also bear any sudden changes of temperature without fracture, and be unacted on by the materials which it may contain. For certain chemical purposes small crucibles are made of platinum.

Crucible Steel (*Eng.*) Cast steel (*q.v.*) made by the cementation process.

Crucible Tongs (*Met., Chem., etc.*) Tongs with jaws suitably shaped for lifting crucibles.

Crucifix. A figure representing the dead or dying form of Christ on the Cross.

Crude Carbolic. *See* GAS MANUFACTURE: COAL TAR DISTILLATION.

Crude Oil. *See* GAS MANUFACTURE: COAL TAR DISTILLATION.

Crup Butt (*Leather Manufac.*) The crup is a small portion of the horse hide. It is cut from the portion over the loins of the horse, is more waterproof than the other part, and on account of its greasy and soft nature is valuable for the uppers of boots, especially shooting or fishing boots.

Crushing Strain (*Eng.*) A strain caused by simple compression.

Crust of the Earth (*Geol.*) A term applied, somewhat vaguely, to such parts of the earth's outer envelope as are accessible to human observation, or which there is reason to think are represented by any kind of rock now appearing at the surface.

Crutch (*Clocks, etc.*) The lever fixed to the verge or pallet arbor (*q.v.*) of a clock for the purpose of conveying energy from the pallets to the pendulum.

Crutch-head. (*Her.*) Known as Potent (*q.v.*)

Crutcher (*Chem., Eng.*) A wooden plunger used to agitate soap in the cooling frames. The act of "crutching" prevents the soap separating into two liquids, and also incorporates the materials used for "filling" (*q.v.*) Special crutching machines are now made on the Archimedean screw principle.

Cryohydrates (*Phys., Chem.*) If a solution of a salt be made of a particular strength depending on the nature of the salt, and this solution be cooled to a particular temperature also depending on the nature of the salt, the whole solution solidifies; the solid thus produced is called a CRYOHYDRATE. At one time cryohydrates were thought to be definite compounds, but it is now known that they are only mixtures. The cryohydric temperature is the lowest that can be obtained by mixing the two components. For water and salt the proportions are 76·2 to 23·8, and the cryohydric temperature is $-22°$.

Cryolite (*Min.*) A fluoride of aluminium and sodium, $3NaF.Al_2F_3$. Aluminium = 13, sodium = 32·8, fluorine = 54·2 per cent. It is a white lamellated mineral with a perfect cleavage; small fragments fuse easily. It is a source of aluminium, and is also used in the manufacture of a porcelain glass. It comes chiefly from West Greenland.

Cryophorus. A piece of apparatus to show that water becomes cooled by its own evaporation. It consists of two glass bulbs connected by a glass tube. This is partly filled with water, which is boiled to expel air and then sealed up while steam is issuing. To use it, the water is collected in one bulb and the empty bulb placed in a freezing mixture; then the rapid condensation of vapour in one bulb sets up rapid evaporation in the other, with the result that the water falls in temperature until it freezes.

Crypt (*Architect.*) A chamber in a building below the level of the ground.

Crystal (*Min.*) A crystal is a geometric solid composed of a substance of definite composition, with a definite internal arrangement of the molecules. Crystals are, in the great majority of cases, bounded by plane surfaces called FACES; each geometric figure or FORM, many of which may be combined in one crystal, consists of two or more faces. For the various types of crystals, *see* SYSTEMS OF CRYSTALS.

Crystalline Rocks (*Geol.*) Strictly speaking, this term may be applied to any rocks in which a crystalline structure can be made out. More usually, however, the term has now come to mean rock other than the normal or unaltered forms of stratified rocks. Thus gneiss, granite, diorite, and various other rocks of eruptive origin, as well as schists, are understood to come under this designation.

Crystallisation. The process of formation of crystals (*q.v.*) The material must, as a rule, be in the liquid state, thus permitting a free movement of the molecules, which can then take up the definite regular arrangement which is an essential feature of a crystalline substance.

Crystallites (*Min., etc.*) A convenient designation for the embryo stages of development from which crystals of rock-forming silicates afterwards arise. In an arrested stage of development crystallites are often met with in eruptive rocks of vitreous structure.

Crystallographic Notation (*Min.*) The method of indicating the relation of a given crystallographic form to the axes of the crystal. There are many different notations; the one most used now is Miller's, in which the indices are integral numbers proportional to the reciprocals of the various intercepts on the axes.

Crystallographic Systems (*Min., etc.*) *See* SYSTEMS OF CRYSTALS.

Crystallography. The science dealing with the forms and nature of crystals. *See* SYSTEMS OF CRYSTALS.

Crystalloids (*Phys.*) Bodies capable of rapid diffusion when in solution, as opposed to COLLOIDS (*q.v.*) The majority of them can be crystallised; hence the name.

Crystals, Systems of (*Min., etc.*) *See* SYSTEMS OF CRYSTALS.

Cs (*Chem.*) Symbol for Cæsium (*q.v.*)

Cu (*Chem.*) Symbol for Copper (*q.v.*)

Cube. A regular solid whose faces are six equal squares.

Cubebs (*Botany*). *Piper cubeba* (order, *Piperaceæ*). The drug is, like pepper, the dried unripe fruit.

Cubic Space (*Hygiene, Ventilation*). The cubic capacity of a room is ascertained by multiplying the length by the width and then by the height. It is a fallacy to suppose that air space does away with the necessity for the renewal of air. Even the air of the largest rooms will in time become vitiated. Basing calculations on the amount of carbon dioxide exhaled per individual per hour, it is found that each person requires 3,000 cubic feet of air during that period. The free air space provided for each person should be not less than 1,000 cubic feet, provision also being made for renewal of the air three times in the hour. Unfortunately this standard is not often reached. The following shows the cubic space per individual in various places:

Schools	130	cubic feet per head.
Common Lodging Houses	300	" "
Factories and Workshops	250	" "
Barracks	600	" "

In hospitals a much greater amount of cubic space should be allowed.

Cubic System (*Min.*) One of the crystal systems. Also called ISOMETRIC, TESSERAL, REGULAR, and MONOMETRIC. In it there are three axes, all equal and all at right angles, so that no one can be regarded as the principal. There are nine planes of symmetry. *See* SYSTEMS OF CRYSTALS.

Cucurbit (*Chem. Eng.*) The body of a still: the belly of an alembic or retort.

Cuir Bouilli, Cuir Bouilly. Boiled leather. The term was sometimes applied to leather armour used in the Middle Ages. Cuir bouilli was often ornamented by impression and manufactured into various articles of dress. In the sixteenth century it was used for hangings for rooms, and when decorated with gold or silver was known respectively as CUIR DORÉ and CUIR ARGENTÉ.

Cullet (*Glass Manufac.*) Waste glass from broken articles, etc., used for mixing with raw material to aid fusion.

Culm (*Botany*). The jointed stem of certain plants, such as grasses. A synonymous term is HAULM.

—— (*Geol.*) A local name for an impure form of coal found in the Carboniferous rocks of Devonshire. The rocks in which it occurs are often called the Culm Measures. Some of its members are true radiolarian cherts, formed in deep sea water. The stratigraphical position of the Culm Measures may be near the top of the Yoredale Series.

—— (*Mining*). Waste coal mixed with rubbish.

Culvert (*Civil Eng.*) A small tunnel for carrying water.

Cumene (*Chem.*), $C_6H_5 . CH\begin{cases} CH_3 \\ CH_3 \end{cases}$ (Isopropyl benzene), a colourless liquid boiling at 153°: dilute nitric acid oxidises it to benzoic acid. It occurs in coal tar. Prepared by action of isopropyl bromide on benzene in presence of aluminium chloride.

Cumulo Stratus (*Meteorol.*) *See* CLOUDS.

Cumulus (*Meteorol.*) *See* CLOUDS.

Cup. An ornamental vase, with or without handles, mounted on a foot. Originally intended to drink out of.

—— (*Cycle*). The hollow piece which forms the ball race of a ball bearing (*q.v.*)

Cup and Ball (*Gasfitting*). A universal joint on the ball and socket principle, used for hanging gas pendants.

Cupboard. An arrangement of shelves sometimes enclosed with doors. Of great variety of form, and varying from a few simple boards fastened in a recess to elaborate carved pieces of furniture.

Cup Chuck, Bell Chuck (*Eng.*) A chuck with a cylindrical hollow, into which objects to be turned are driven, and held in the hole by friction, by wedges, or by set-screws passing through the wall of the chuck. Chiefly used for light work or for ornamental turning.

Cupel (*Assaying, Chem., etc.*) A small shallow dish of bone ash or some other absorbent material, used when the operation of CUPELLATION (*q.v.*) is conducted on a small scale.

Cupellation (*Assaying, Chem., etc.*) The process of separating a metal from others more readily oxidised, by heating with exposure to air on a hearth made of some porous material which will absorb all or part of the oxides produced, while the metal it is desired to obtain remains as a fused regulus at the bottom of the hearth. Such a porous hearth is called a cupel, and is made of bone ash or a cheaper substitute (mixture of clay and limestone). An example is the separation of silver from lead. *See* LEAD.

Cup Leather (*Eng.*) A leather ring, produced by forcing a flat ring of leather into a mould until its cross section becomes the shape of letter U. Used as packing for the pistons of pumps and hydraulic rams. The material is technically known as HYDRAULIC LEATHER (*q.v.*)

Cupola (*Architect.*) A curved or cup-shaped roof, covering a square, polygonal, or circular chamber. This form of roof is also known as a DOME (*q.v.*)

—— (*Met.*) A cylindrical iron furnace lined with firebrick: used for melting cast iron in the foundry. It is worked by means of a blast, and has the necessary openings for introducing the charge and for withdrawing the slag and fluid metal.

Cupola Blast Furnace (*Metallurgy*). A small form of blast furnace built with an external iron case, like a cupola.

Cupric Compounds, Copper. *See* COPPER COMPOUNDS.

Cuprite (*Min.*) The red oxide of copper, Cu_2O. Copper = 88·8, oxygen = 11·2 per cent. It crystallises in octahedra of the Cubic System, but is also found massive, earthy (TILE ORE), and in capillary crystals (CHALCOTRICHITE). It is worked as an ore of copper. Good crystals have an adamantine lustre, are translucent, and of a deep ruby red colour. From many Cornish mines, Devonshire, Spain, France, Siberia, Lake Superior, Australia, etc.

Cuprous Compounds. *See* COPPER COMPOUNDS.

Cuprum, Cupric, Cuprous. Cuprum is the Latin name for copper, and from it is derived the symbol for copper, Cu. Copper forms two series of salts: those containing more copper are called cuprous, those containing less are called cupric, salts. *See* COPPER COMPOUNDS.

Curare *or* **Curara** (*Botany, Chem.*) The well known arrow poison of South America; is obtained by maceration of the bark of *Strychnos toxifera* (order, *Loganiaceæ*). Used in medicine. It is said to contain an alkaloid termed CURASINE, but this is probably not a single substance.

Curator. A person in charge of a picture gallery or museum.

Curb (*Carp.*) (1) The horizontal timbers under the sill of a lantern light. (2) The plate to which the feet of the top rafters and the top ends of the lower rafters are fixed in a Mansard roof.

—— (*Chem. Eng.*) The upper, conical, or barrel-shaped part of a soap-kettle or copper where it is widened to prevent boiling over. A Fan Curb is a modern form in which two paddle wheels or beaters on a horizontal shaft are operated beneath the surface of the soap by a vertical shaft and bevel gear.

—— (*Mining*). The frame used in sinking a shaft, which supports the lining.

—— *or* **Curb Ring** (*Eng.*) An annular wheel (*q.v.*) fixed on the bed plate of a crane and used for rotating the crane.

Curcumin (*Chem.*), $C_{14}H_{14}O_4$. Orange-yellow prisms melting at 178°: it is the colouring matter of turmeric root: obtained from the root by extraction with ether after it has been distilled with steam; it is a weak acid. Alkalis turn it brown. The action of boric acid is characteristic; this acid turns it reddish brown. Hydrochloric acid does not change this colour, while acids change the brown produced by an alkali back to yellow.

Curd of Milk (*Foods*). When an acid is added to milk, curds and whey are formed. The former consists of casein (the proteid of milk) and fat, while the liquid whey contains the sugar, salts, etc. The curd of cow's milk is not so digestible as that of human milk; this may be counteracted by adding barley water and lime water to milk intended for infants. Cheese is prepared from the curd, while casein is always present in butter. *See* COW'S MILK.

Cure (*Leather Manufac.*) A material or solution of a material capable of curing or arresting the decomposition of animal hides or skins. The most common "cures" in use are salt, arsenic, boracic acid, and compounds of carbolic acid. *See also* DEPICKLING.

Curing (*Leather Manufac.*) Treating hides or skins with a cure (*q.v.*), generally for the purpose of preserving them during transport.

Curiosities (*Art, Archæol.*) Objects of interest, valued for their antiquity, rareness, or costliness.

Curl Yarn (*Woollen Manufac.*) A compound thread in which one of the strands is formed into curls or loops.

Current Bedding (*Geol.*) Another term for what is more usually known as FALSE BEDDING or as CROSS STRATIFICATION. The rocks in which it occurs are usually either sandstones or conglomerates. In all cases the planes of original deposition were not parallel to the horizon. The structure is due to deposition by the action of bottom currents.

Current Density (*Elect. Eng.*) The amount of current per unit of area of cross section of a conductor. A common rule for determining the size of a conductor is to allow 1,000 ampères per square inch, but this requires much modification according to the depth to which the conductor is covered and its facilities for radiating away the heat produced by the passage of the current. This rule only takes into consideration the heating limit, and is useful in wiring buildings. In main conductors for supplying current from central stations the current density is determined by the percentage loss of energy in them, which usually becomes excessive long before the heating limit is reached.

Current, Electric. Electricity in motion, flowing from place to place along a conductor.

Currying (*Leather Manufac.*) A process by which grease is put into tanned leather to make it pliable and water resistant. Harness, belting, boot uppers, straps, etc., are always curried.

Curtail Step (*Carp. and Join.*) A step with a scroll end.

Curtain (*Chem. Eng.*) The sheet lead portion of a vitriol chamber suspended over the "saucer." It resembles a rectangular box suspended upside down over its lid, the lid being the "saucer." The mouth of the curtain is sealed by a layer of acid in the saucer.

Curtain Machine (*Lace Manufac.*) A twist lace machine especially adapted for the production of lace curtains. The principal feature is its capacity for the reproduction of design on an extensive scale.

Curule Chair. *See* CHAIR, CURULE.

Curvature. The curvature of a line is measured by the reciprocal of its radius of curvature (*q.v.*). The curvature of a surface is the sum of the curvatures of two cross sections of the plane, made by two planes cutting the surface at right angles to each other.

Curve Ranging (*Surveying*). Marking out on the ground a series of points through which a curve of a given radius passes.

Curves, Magnetic. *See* LINES OF FORCE.

Curves of Magnetisation (*Elect. Eng.*) Curves showing the relation of the magnetising force to the intensity of magnetisation or to the magnetic induction produced by it in any given sample of iron or steel.

Curvilinear (*Architect.*) One of the periods into which Sharpe divided English Gothic architecture. His division, based on the form of the windows, is as follows:

Anglo-Saxon	449—1066
Norman	1066—1149
Transitional	1149—1190
Lancet	1190—1245
Geometrical . . .	1245—1315
CURVILINEAR . . .	1315—1360
Rectilinear . . .	1360—1550

The windows of the curvilinear type have tracery in which the bars are formed into undulating curves (flowing tracery) or tracery formed in reticulated or netlike forms. *See* DECORATED *and* RETICULATED.

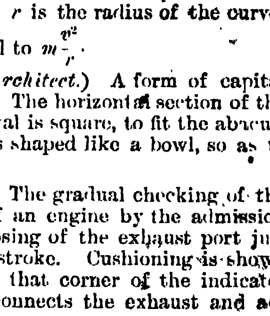
Curvilinear Motion. Motion along a curved line. To maintain such motion of a body a force must be exerted on it directed towards the centre of curvature of the curve. If v is the velocity and m the mass of the body, and r is the radius of the curve, the force must be equal to $m\frac{v^2}{r}$.

Cushion Capital (*Architect.*) A form of capital used in Norman work. The horizontal section of the upper part of this capital is square, to fit the abacus, while the lower part is shaped like a bowl, so as to fit a circular shaft.

Cushioning (*Eng.*) The gradual checking of the motion of the piston of an engine by the admission of steam or by the closing of the exhaust port just before the end of the stroke. Cushioning is shown by the rounding off of that corner of the indicator diagram (*q.v.*) which connects the exhaust and admission lines.

Cushion Tyre (*Cycle, etc.*) A tyre consisting essentially of a very thick-walled rubber tube, the walls of the tube itself being thick enough to supply a certain amount of resilience without inflation. Cushion tyres may be said to have been intermediate between the old solid tyres and the modern pneumatics, but they were always unsatisfactory, and are practically extinct.

Cusps (*Architect.*) The projecting points producing the leaf-shaped forms or foils of Gothic tracery. In the Early English period, during which cusps were introduced, they were worked on the soffit of the tracery bar or arch, and had the appearance of having been attached to it as an afterthought. In later work the inner moulding of the bar adjacent on the soffit was continued on the cusp, so that the latter appears to be an essential part of the tracery bar. *See* FOILS.



CUSP.

Cut (*Art*). A print from a wood block is sometimes called a "cut." *See* CUTS.

—— (*Cotton*). A woven piece length of cloth.

—— (*Eng., etc.*) A process of removing metal or wood by means of a cutting tool. "Heavy" cut, "light" cut, etc., are usual expressions referring to the amount of material removed at a time.

—— (*Linen Manufac.*) When the yarn is being reeled into hanks, the latter are made up of small parcels of a hundred and twenty threads, or 300

yards in length, which are called CUTS or LEAS. There are usually twelve cuts to one hank, but sometimes only ten. *See* CUTS.

Cut and Mitred String (*Join.*) A cut string (*q.v.*) used in a staircase in which there are no ornamental brackets to conceal the junction of the risers (*q.v.*) with the string. The junction is made in this case by means of a mitred joint. *See also* STAIRCASES.

Cuticle (*Botany*). The outer layers of the walls of epidermal cells. The original cellulose of the wall becomes converted into a strong waterproof substance—CUTIN. *See* RAFFIA.

—— (*Zoology*). (1) A thin membrane formed by a SECRETION (chitin) of the outer surface of many invertebrate animals (example, earthworm, crayfish, etc.) (2) The outer or horny layer of the epidermis of the mammalian skin. It is composed of dead cells, whose protoplasm is converted into KERATIN (*q.v.*)

Cutlas (*Arms*). A short heavy sword with a wide curving blade, intended rather for cutting than thrusting. This weapon was formerly used by sailors.

Cut-Off (*Eng.*) The point at which the admission of steam to a cylinder is stopped. It usually varies from a quarter to threequarters of the stroke, and is determined by the lap (*q.v.*) in the case of the ordinary slide valve. Variable cut-off is obtained by the use of a separate valve called the Expansion Valve in ordinary engines, or by controlling the action of the admission valves in Corliss engines.

Cuts (*Typog.*) A term used by printers for illustrations of any kind.

—— (*Woollen Manufac.*) The Scotch term for counts (*q.v.*) Galashiels cut is a length of 300 yards in 24 oz., and the Hawick cut the same length in 26 oz.

Cut String (*Join.*) A string (*q.v.*) in a staircase which has its upper edge cut out into a succession of rectangular notches, the edges of the notches being alternately vertical and horizontal, corresponding to the risers and treads (*q.v.*)

Cutter (*Build.*) A soft brick used in gauged arches. Also termed a RUBBER or RUBBING BRICK. *See* BRICKS.

—— (*Eng., etc.*) The actual cutting part of a machine tool, especially the rotating cutting wheel used in milling, wheel cutting, and similar machines.

Cutter Block (*Eng., etc.*) The holder which carries the tool. The term is especially applied to woodworking machinery.

Cutters (*Geol.*) A term for a set of JOINTS (*q.v.*) cutting through a rock at right angles to the set termed BACKS (*q.v.*)

Cutting (*Civil Eng.*) An open trench by which a railway, etc., is carried through ground of moderate elevation. The material of the cutting is used to form embankments on one or both sides of the hill, giving gradual approaches to the cutting, and utilising the material removed without the necessity of transport to a distant point.

—— (*Chem. Eng.*) The separation of soap (in the soap-copper) from the glycerol and aqueous fluids in the half-made or "close" soap, by the addition of salt or brine, in which the grain soap is insoluble. Also termed GRAINING.

Cutting Blast (*Metallurgy*). Air forced into a furnace under too high a press— wasteful consumption of fuel.

Cutting Edge (*Eng., etc.*) The actual edge of a tool. The angle varies with the nature of the material, being usually most acute for the softest materials.

Cutting Face (*Eng., etc.*) The flat surface of a cutting tool, which serves to turn over or break the shaving as it is removed.

Cutting Gauge (*Carp., etc.*) A gauge for cutting thin wood. It resembles a marking gauge, but has a sharp-edged cutter instead of a scribing point, so that it makes a cut instead of a scratch on the surface, and can therefore be used for dividing thin material.

Cutting Up (*Foundry*). When fresh sand is to be added for mending a broken part in a mould, the surface of the broken part is first roughened, in order that the new sand may adhere properly. This roughening is termed CUTTING UP.

Cuttlefish. *Sepia officinalis* (class, *Cephalopoda*). A naked mollusc, possessing an internal shell or CUTTLE BONE. The sepia is used as food in many countries, while the "bone" forms a polishing material, and the ink bag is the source of the pigment SEPIA (*q.v.*)

Cuvette (*Glass Manufac.*) The vessel in which molten plate glass is carried to the casting table.

—— (*Met.*) A Parting Flask (*q.v.*)

Cyanic Acid (*Chem.*), HCNO. A liquid only stable below 0°; above this it polymerises to a white solid called cyamelide. It is prepared by heating cyanuric acid, $H_3C_3N_3O_3$. From cyanic acid the salts called cyanates are derived. Only one form of cyanic acid is known; but there are two formulæ possible for it, namely (1) N ⋮ C . OH ; (2) HN : CO. Salts derived from form (1) are called CYANATES; salts from form (2) are called ISOCYANATES. *See* TAUTOMERISM.

Cyanides (*Chem.*) Salts of hydrocyanic acid (*q.v.*) *See* POTASSIUM CYANIDE, *under* POTASSIUM COMPOUNDS, *and* MERCURIC CYANIDE, *under* MERCURY COMPOUNDS. The organic cyanides are called NITRILES (*q.v.*)

Cyaniding (*Met.*) A method of extracting gold from "slimes" (*q.v.*) and poor ores by treating them with a solution of alkaline cyanide which dissolves the gold.

Cyanite (*Min.*) *See* ANDALUSITE.

Cyanogen (*Chem.*), $\begin{array}{c} C \vdots N \\ | \\ C \vdots N \end{array}$. A colourless gas with characteristic smell: extremely poisonous: somewhat soluble in water (1 in 4), but the solution decomposes, giving ammonium oxalate, a brown solid called azulmic acid, and other products. It burns with a purple flame to nitrogen and carbon dioxide. With caustic potash it gives a mixture of potassium cyanide and cyanate. It is obtained by heating mercuric cyanide or a mixture of potassium cyanide and copper sulphate solutions.

Cyanotype (*Photo.*) *See* BLUE PRINT.

Cyanuric Acid (*Chem.*), $C_3H_3N_3O_3$. A white crystalline solid readily soluble in hot water and in alcohol. When heated it gives cyanic acid (*q.v.*) It is obtained on heating urea.

Cyathus (*Archæol.*) A drinking cup or small ladle used by the Greeks and Romans for drinking wine or for drawing it from the crater (*q.v.*) It was also a measure = about one-twelfth of a pint.

Cycle. (1) A complete set of physical or chemical operations, such as the processes undergone by the working substance in the cylinder of an engine. (2) A general term for a light vehicle propelled by the rider. The legal expression, still frequently used in patent specification, is "Velocipede." *See* CYCLES.

Cycles. A modern cycle consists of four chief sets of parts: (1) the frame, (2) the wheels, (3) the tyres, (4) the equipment, which includes the saddle, brakes, chain, ball bearings, etc. The frame is generally formed of thin seamless steel tubing, which is "solid drawn" (*q.v.*) There is also a form of tube known as "helical," which is formed from a thin steel band or ribbon, wrapped into the form of a tube and brazed at the edges. It is immensely strong, and is quite distinct from the inferior form of tube known as "lap welded," which is used in some low-grade machines. The joints at the points where the tubes meet or are joined together to form the frame are made by means of "lugs," which are "drop forged" in the best machines, *i.e.* are forged as solid pieces from suitable steel under a mechanically worked hammer. The lugs are drilled out to fit the tubes, which are then brazed in, or in the case of "flush joints" the lug goes inside the tube, which is brought up close to the head of the lug, thus making a very neat joint. The wheels consist of a steel rim, which may be either hollow or solid. The rims are generally mechanically rolled and shaped from flat steel strips; the overlapping ends are brazed together and ground until the joint is smooth and imperceptible when enamelled. In the best form the rim is stamped from one piece of steel, without any joint whatever. It is then "spun" into shape and provided with a liner to strengthen it and take the tyre. The spoke heads are provided with washers to prevent them pulling through the thin rim. The wheel rim is attached to the hub by means of steel wire spokes (about ·05 in. in diameter), which are in tension instead of being adapted merely to take compression, as is the case in the wheel of an ordinary vehicle. It was the discovery of the "suspension" method of building a wheel in 1868-9 which enabled a cycle to be made of the light materials now used; for if the spokes had to be in compression, they would have to be sufficiently stiff to withstand bending, and therefore enormously heavier than at present. The hub of a bicycle wheel is shown in figs. 1 and 2. In both cases A represents the axle, which does not rotate, but is fixed by a locking nut N to the fork F. The rotating portion, or hub proper, is shown in section at H, the spokes being attached to the flange at S. The hub is bored out to a larger size than the axle, so that the barrel of the hub does not come into contact with the fixed axle at all, but acts as an oil retainer. The actual bearing surface is produced by contact with steel balls BB. In fig. 1 there is a conical collar on the axle, and the hollow cone C is screwed into the hub until there is easy contact between the cone on the axle, the ball B, and the hollow cone C, the space between these forming the ball race. In the second case, fig. 2, the cone C is screwed on to the axle, and can be moved backward and forward to make an adjustment of the bearing until the ball B is in touch with this and the hollow cone in the hub. In the case of the back wheel the chain wheel or pinion is attached to the hub itself by a screw thread; the axle is held in a slot in the rear fork ends, and by means of an endless screw can be drawn back in order to tighten the chain. In the front wheel the hub turns freely, without any control, on the fixed axle. The lowest part of the frame is termed the BOTTOM BRACKET, and is shown in fig. 3. The crank axle which runs through the bottom bracket can turn freely in the ball bearing shown. On to this axle the cranks and the chain wheel are rigidly keyed. Sometimes the crank arm and axle are in one—the other crank being secured by a chain attachment. This chain or SPROCKET WHEEL is connected by the steel chain, which forms the driving band described below, to the small chain wheel which is fixed to the hub of the back wheel. In the older type of machine, known as the FIXED WHEEL machine, the chain wheel and hub must turn together at all times; but in modern machines the wheel is said to be "free," that is the sprocket wheel, rear pinion, chain, cranks, and pedals may remain stationary, while the rear wheel runs freely. A form of free-wheel clutch is shown diagrammatically in fig. 4. A is a wheel or rim which is rigidly fixed to the hub, and must always turn with it; it carries pawls or ratchets D; B is a steel rim provided with teeth CC, and BB are the ball bearings. The ratchets or pawls D are either

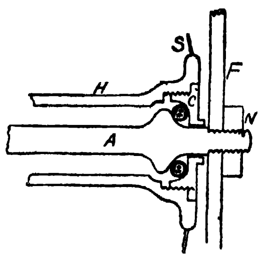


FIG. 1.

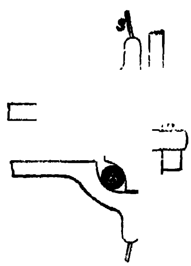


FIG. 2.

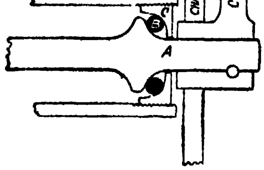


FIG. 3.

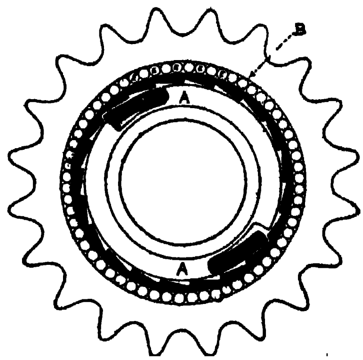


FIG. 4.

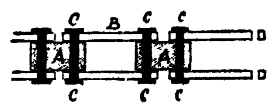


FIG.

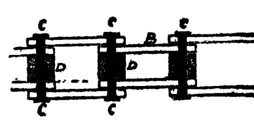


FIG. 6.

caused to drop between the teeth CC of the ratchet wheel by springs, or, in the more popular machines, are actuated by gravity. It is easily seen that if the outer portion B remain at rest, the inner portion A can revolve in the direction of the hands of a clock; but if B revolve, it is bound to carry A with it. When the cycle is pedalled, B will be driven by the chain in such a manner that A revolves with it; on ceasing to pedal, the rim B remains still, and the machine runs on, causing A to revolve in the same direction as before, the pawls D dropping automatically and passing each tooth in turn. Thus the back wheel of the cycle can continue to revolve, and the machine runs on, while the pedals, cranks, chain, and the outer part B of the wheel all remain at rest. In what is termed the "clutch" form of freewheel the connection between A and B is made by some form of friction clutch; but this is now being abandoned in many forms of machine in favour of some type of ratchet wheel, which is more certain in its action. *Chains:* There are two main types of chain, shown in figs. 5 and 6. In fig. 5 a series of solid blocks AA are connected to side links B by means of pins CC, forming what is termed a BLOCK CHAIN. In the second type the side link B is connected by pins CC, which pass through rotating rollers D, forming what is termed the ROLLER CHAIN. In this form the friction of the chain is diminished to a considerable extent. Friction is further diminished by protecting the

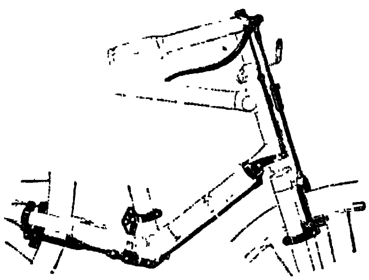


FIG. 7.—B.S.A. BICYCLE BRAKE FOR ORDINARY FRAME.

chain from dust and grit. The best method of doing this is to enclose both chain wheels and the whole of the chain in a thin metal GEAR CASE, which contains a small bath of oil, through which a portion of the chain is continually running, thus keeping the whole well lubricated and free from grit. The STEERING PILLAR is the upright rod by which the front forks are connected with the handle bar; over this is the outer sleeve to which the upper and lower frame tubes are joined; at the top and bottom of this sleeve are placed ball bearings in the head of the machine, and form a practically frictionless joint between the frame and front portion of the cycle. The pedals also run on ball bearings. By this means internal friction is reduced to a minimum. What may be termed the external friction—that due to the road—depends largely on the nature of the tyres, which are dealt with elsewhere. *See* TYRES. Now that freewheels are practically universal, it has become necessary to give much more attention to the subject of brakes. The old spoon brakes, which press directly on the tyre, were fairly satisfactory for solid tyred machines, or even for pneumatic tyres (except in case of a puncture), when the machine could also be checked by back pedalling; but in a freewheel machine, where back pedalling is impossible, greater brake power is required, and this is usually obtained by using brakes which act on the rims of both back and front wheels. The front wheel brake usually carries two blocks on a horseshoe-shaped clip, which is drawn upward by the brake levers, and presses on the lower (outer) surface of the rim at the top of the wheel. The back wheel brakes are generally made to act on the rim also, and are worked either by a series of levers or else by a flexible cable consisting of fine twisted steel wires running through a tube, as in the Bowden brake. By this plan, now largely employed in mechanics, power can be taken round corners by a (seemingly) slack wire without loss. In other cases the back wheel carries a drum about 5 or 6 in. in diameter, on which a band brake acts. This may be worked either from the handle bar or by mechanism connected by the crank shaft, so as to be brought into play when slight back pedalling is exerted. Other varieties of back pedalling brakes are also fitted; but as a general rule a good rim brake on the back wheel, in conjunction with the front, is more simple and also more reliable than these devices. *Tricycles:* The modern tricycle is almost invariably built with a front wheel fork and frame arranged as in the bicycle; the back fork is widened out to carry the long axle on which the two back wheels turn. The only important mechanical difference between the bicycle and tricycle, then, consists in the addition of what is termed "Differential Gear" (*q.v.*) placed in the centre of the axle. This enables one wheel to turn to a certain extent independently of the other when the machine is describing a curved path, *e.g.* turning a corner; but when the machine is going straight forward, the differential gear transmits the motion of the chain to both wheels equally. *See also* MOTOR CYCLES, SPEED GEARS, *and* TYRES.

Cyclometer. A small instrument for recording the distance run by a cycle or car by registering the number of revolutions of the wheels. The instrument contains a train of gear wheels, and a dial (or other indicator) usually graduated to read directly in miles.

Cyclone (*Meteorol.*) A system of winds in which the currents are circulating in a direction opposite to the hands of a watch; it is also an area of barometric depression, which becomes greater as the centre of the area is approached. In an ANTI-CYCLONE the motion and conditions of pressure are the opposite of those in a cyclone; the atmospheric pressure is greatest in the centre, and the air currents are in the direction of the hands of a watch. The whole system usually has a motion of translation.

Cylinder. (1) A geometrical solid produced by the revolution of a rectangle about one edge. (2) In engineering, a solid of this form, and also a vessel containing a cavity of the form of a cylinder, especially the cylinder of an engine. *See* STEAM ENGINE, *etc.*

—— (*Lace Manufac.*) That part of the Jacquard which presents each card in succession to the needles. It may be either square or hexagonal in shape, and of either wood or brass, each face or side having sufficient area to embrace the number of needles used, every needle being represented by a corresponding hole in each face of the cylinder. The holes in the card must be in perfect register with the holes in the cylinder, and the needles with both.

—— (*Watches*). The hollow cylinder on which is mounted the balance of the "horizontal" watch; it acts both as balance staff and pallets

Cylinder Bit. A long bit or drill with a cutting edge parallel to its axis, used for boring very accurate holes; a shallow cavity is first formed for entering the bit.

Cylinder Bore (*Eng.*) The internal diameter of the cylinder of an engine, etc.

Cylinder Cover (*Eng.*) Circular discs of cast iron, which may be flat, ribbed, or "dished" (*q.v.*), forming the ends or covers of the cylinder of an engine.

Cylinder Flanges (*Eng.*) Rings cast on a cylinder to which the covers are bolted.

Cylinder Lubricating Oil (*Eng.*) This must be a good lubricating oil, which will not corrode the cylinder nor gum, or form a deposit due to decomposition by the steam or other heated gas in the cylinder. Some mixture of mineral oils is usually superior to any animal oil.

Cylinder Lubricator (*Eng.*) A device for admitting oil to the cylinder for lubricating the piston. In gas engines a mechanical device is necessary for keeping up a constant supply of oil. In high-speed engines, which are often made single acting (*q.v.*), the crank is enclosed in a chamber containing oil. This communicates directly with the cylinder, so that when the crank revolves, it distributes the lubricant over the crank bearings, connecting rod, and the bore of the cylinder.

Cylinder Metal (*Eng.*) Iron which when polished has a low coefficient of friction, *i.e.* SLIPPERY IRON (*q.v.*): used for cylinders and any surface of cast iron where much friction occurs.

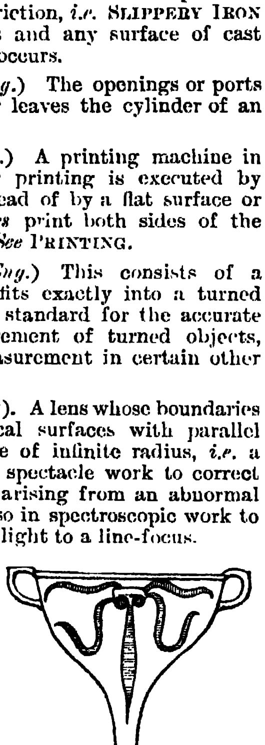
Cylinder Passages (*Eng.*) The openings or ports by which steam enters or leaves the cylinder of an engine.

Cylinder Press (*Typog.*) A printing machine in which the impression or printing is executed by means of a cylinder instead of by a flat surface or platen. *Double Cylinders* print both sides of the paper at one operation. *See* PRINTING.

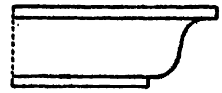
Cylindrical Gauge (*Eng.*) This consists of a cylindrical block which fits exactly into a turned collar or ring; used as a standard for the accurate reproduction and measurement of turned objects, and as a standard of measurement in certain other cases.

Cylindrical Lens (*Light*). A lens whose boundaries are portions of cylindrical surfaces with parallel axes; one surface may be of infinite radius, *i.e.* a plane. They are used in spectacle work to correct certain defects of vision arising from an abnormal form of the eye itself; also in spectroscopic work to convey a parallel beam of light to a line-focus.

Cylix, Kylix. A rather broad and shallow cup with two handles and a stem, used by the ancient Greeks: a Tazza.


CYLIX.

Cyma (*Architect.*) A compound moulding formed by the conjunction of a cavetto and an ovolo. It is also known as the OGEE. There are two varieties: the CYMA RECTA, in which the ovolo is below the cavetto; and the CYMA REVERSA, in which the cavetto is below the ovolo.


CYMA RECTA.


CYMA REVERSA.

Cymatium. A small moulding usually crowning another feature. Each of the following features is usually known as a cymatium: The upper mouldings, generally a fillet and a cyma reversa, of the abacus of a Roman Doric capital; the crowning mouldings of the architrave of the Ionic and Corinthian Orders; the moulding capping the horizontal cornice under the tympanum of a pediment. *See* COLUMN; ARCHITECTURE, ORDERS OF; IONIC; CORINTHIAN; *and* PEDIMENT.

Cymbal. *See* MUSICAL INSTRUMENTS, PERCUSSION (INDEFINITE SOUND).

Cymene (*Chem.*), $C_6H_4\begin{cases}{}^{(1)}CH_3 \\ {}^{(4)}CH(CH_3)_2\end{cases}$ (1 : 4), methyl isopropyl benzene. Liquid: boils at 175°: pleasant smell. It occurs in many essential oils, and especially in those of eucalyptus and caraway. It is obtained by heating camphor with phosphorus pentoxide or pentasulphide, also by heating turpentine with iodine.

Cypress. *See* WOODS.

D (*Music*). The second note in the scale of C.

Dabber (*Engrav., etc.*) A tool with a padded end, used to apply ink or other substance evenly to a surface—*e.g.* engraved plates, etc.

Da Capo (*Music*). From the beginning (of a movement). Abbreviated D.C.

Dacites (*Geol.*) Eruptive rocks of hemicrystalline structure, which consist essentially of soda lime felspars with ferromagnesian silicates, some free quartz, and a vitreous or lithoidal ground mass. They usually occur as intrusive rocks. They are the trappean representatives of the plutonic plagioclase granites or diorite granites, on the one hand, and of the quartz-andesites on the other.

Dado (*Architect*). (1) The die of a pedestal. (2) The wall space between the plinth and impost. (3) The lower part of the wall of an apartment when treated similarly to a continuous pedestal. *See* DIE, PEDESTAL, PODIUM, *and* ARCHITECTURE, ORDERS OF.

—— (*Dec., Join., etc.*) (1) Framing round a room, hall, or staircase, made to represent a continuous pedestal. Strictly, the space between the plinth and the capping, a flat surface extending usually to a height of between 3 and 4 ft. above the floor. (2) The painting, distempering, papering, etc., of the lower part of an interior wall when of a colour or material different from that of the upper part.

Dædals (*Archæol.*) Originally applied to archaic wooden effigies which represented deities, and were supposed to be carved by Dædalus, the constructor of the famous labyrinth at Crete.

Dag (*Arms*). A heavy pistol used in the sixteenth and seventeenth centuries.

Dagger (*Arms*). A short, pointed sword used at short quarters for killing or wounding an adversary by a thrust or stab. The early varieties, known as MISÉRICORDES, were worn by both military and civilians, and had no crossguard.

Dagges (*Cost.*) The cuttings or slashings round the edges of a garment. Sumptuary laws were passed to limit the same as early as 1188.

Daguerreotype. A photograph produced by the process introduced by Daguerre in 1839. A silver plate was used, which was rendered susceptible to the action of light by iodine; mercury vapour developed the picture.

Dais. (1) Formerly the elevated end of a hall whereon those of higher rank stood or sat; also the raised table in a hall at which distinguished persons sat. (2) The platform of a lecture hall. (3) The raised floor on which a pulpit stands.

Dalmatic (*Cost.*) (1) An ecclesiastical vestment. This garment was worn under the chasuble, but over the stole, tunic, and alb. The sleeves are wider and longer than those of the tunic. Generally made of white silk with purple stripes, but sometimes of other materials and colours. (2) A vestment worn by sovereigns at their coronation.

Dal Segno (*Music*). From the sign : marked :𝄋: Abbreviated D.S. Dal Segno is used when the repeat is not from the beginning.

Dalton's Atomic Theory (*Chem.*) *See* ATOMIC THEORY.

Dalton's Law (*Phys.*) If one or more liquids are introduced into a space of given volume, the amount of vapour given off by each depends only on the temperature, and is independent of any other gas or vapour present; and therefore the total pressure of the gases and vapours contained in the space is the sum of the separate pressures which each would exert if it were the only one present. The law does not hold good when the respective liquids and gases act chemically on one another.

Dam (*Civil Eng.*) (1) A barrier across a stream, etc., to keep back the water or to raise its level. (2) A watertight enclosure entirely surrounded by water; the water can be pumped out of the inside, and engineering or other operations carried on in the bed of the stream. Usually called a COFFER DAM.

—— (*Mining*). A partition used to keep out water or foul air from a working.

Damask (*Archæol.*) Originally the name for articles produced in Damascus, as DAMASK BLADE of a sword: subsequently used of a rich cloth or fabric of wool, silk, etc. elaborately figured or embroidered. *See* DAMASKENE.

—— (*Cotton Weaving*). A style of figured weaving in which the design is reversible and usually constructed on the warp and weft satin weave, so that all along floats are avoided and a well bound cloth is produced. Sometimes the name is used to distinguish a warp-figured cloth from a brocade.

—— (*Linen Manufac.*) In the linen trade, as in others, damask is a figured fabric, mostly used for table linens. It is usually called single or double damask, though there is not much difference, except that the former is the thinner and usually the coarser material, the double damask being a richer and better article, and showing out the pattern better. But for a cheap damask the good single one will wear better.

—— (*Silk Manufac.*) A figured silk fabric made from the combined action of mounture and satin harness, consisting usually of five or eight shafts. The mounture raises figure, whilst harness, if five shafts, raises one-fifth of warp threads and depresses another one-fifth for each pick. The result is satin ground with dull plain figure, the back of the work being exactly the reverse of the face. *See* HARNESS, MOUNTURE, SILK MANUFACTURE.

Damaskene, Damaskeen, *or* **Damascene** (*Archæol.*) As damask came to be applied to rich textile fabrics, damaskene was used for the embellishment or enrichment of metallic surfaces. *See* DAMASK (*Archæol.*)

Dam Board (*Textiles*). *See* DIAPER.

Dammar (*Botany*). A conifer, *Agathis Dammara* (order, *Coniferæ*), closely allied to the Kauri gum tree, yielding the transparent resin Dammar, used in varnish making.

Damp (*Mining*). Foul air, *i.e.* air containing carbon dioxide, etc. *See also* CHOKE DAMP *and* AFTER DAMP.

Damper (*Build., Eng., etc.*) An iron shutter fitted in a flue to regulate the draught.

Damper Weight (*Eng.*) A counterpoise weight attached to a flue damper by a chain passing over a pulley to balance its weight and render it easy to raise or lower.

Damping (*Moulding*). Moistening foundry sand to cause it to be more coherent.

—— (*Phys.*) The checking of motion, particularly of vibratory motion, by the friction of the medium in which the moving body is placed, or by other retarding forces. For example, the amplitude of the vibrations of a sounding body gets less and less, and the sound dies away if the body is left to itself; and similarly a pendulum slowly comes to rest when set vibrating in the air.

Damping Down (*Eng.*) Putting small and damp coal on a fire to cause it to burn very slowly, and hence to keep alight a long time.

Damping Rolls (*Paper Manufac.*) Metal cylinders of small diameter used for damping paper.

Dam Plate (*Met.*) An iron support of the DAM STONE (*q.v.*) in a blast furnace.

Damp Proof Course (*Build.*) A frequent cause of dampness in houses is the rising of moisture in brickwork due to capillary attraction. In order to prevent this, layers of waterproof materials, termed DAMP PROOF COURSES, are constructed. These are placed just above the ground level and across the thickness of the wall; they may be constructed of stoneware slabs with holes for ventilation, sheet lead, or layers of asphalt, tarred jute, or slates floated in cement.

Dam Stone (*Met.*) A stone which prevents the molten iron from flowing out at the base of a blast furnace.

Dan (*Mining*). A small sledge used for dragging weights.

Dancette (*Her.*) Lines dividing a shield similar to indented lines, but larger and deeper. The indentations never exceed three in number.

Dancing Steps (*Carp.*) *See* BALANCED STEPS.

Dandy Roll (*Paper Manufac.*) A skeleton roll covered with wire cloth and carrying patterns or names for the production of "watermarks."

Dangerous Infectious Diseases (*Hygiene*). Included in this expression, as defined by the Public Health Statutes, are the following diseases, namely: smallpox, cholera, diphtheria, membranous croup,

erysipelas, scarlatina or scarlet fever, the fevers known by any of the following names: typhus, typhoid, enteric, relapsing, continued, or puerperal. In addition, the sanitary authority of any district and the County Council in London are empowered to extend notification to diseases other than those set out. It is very important that the occupiers of houses should understand clearly the duties cast on them in regard to the notification of these diseases. Where an inmate of any house within the district of a sanitary authority is suffering from an "infectious disease" (as above), the head of the family to which such inmate belongs, and in his default the nearest relatives of the patient present in the house or being in attendance on the patient, and in default of such relatives every person in charge of or in attendance on the patient, and in default of any such person the master of the house shall, as soon as he becomes aware that the patient is suffering from an infectious disease as above, send notice thereof to the medical officer of health of the district. It must be noticed that the medical practitioner attending on or called in to visit the patient is also made responsible in regard to notifying the medical officer of health. Failure to comply with the Acts in this respect renders the person who is required to send a notice or certificate to the sanitary authority liable to a fine.

Daniell's Cell (*Elect.*) *See* CELLS, PRIMARY.

Daniell's Hygrometer (*Phys., etc.*) *See* HYGROMETERS.

Dark Lines in the Spectrum (*Phys.*) *See* SPECTRUM ANALYSIS.

Darkroom (*Photo.*) A room lit only by light which will not affect a photographic plate, *i.e.* orange or red light of low intensity. A darkroom should be well ventilated and fitted with a table, sink, shelves, and other conveniences for development.

Darkroom Lamp (*Photo.*) A lamp surrounded by an orange or ruby shade, or an electric lamp immersed in a solution of quinine, thus giving non-actinic light.

Darley Dale Stone. *See* BUILDING STONES.

D'Arsonnal Galvanometer (*Elect.*) *See* GALVANOMETER.

Dart (*Arms*). A sharp-pointed weapon thrown by the hand: sometimes used as an arrow.

Dartmoor Granite. *See* BUILDING STONES.

Dash (*Music*). *See* STACCATO.

Dash Piston (*Eng.*) The piston of a DASH POT (*q.v.*)

Dash Plate (*Eng.*) A baffle plate (*q.v.*), which prevents the water in a ship's boiler from flowing suddenly away from the plates of the firebox when the ship rolls.

Dash Pot (*Eng.*) A device for preventing sudden motion of some part of a piece of mechanism by utilising the viscosity or inertia of a fluid. A simple form consists of a small vessel of liquid in which a piston moves loosely. A very small force, steadily applied, is sufficient to cause motion of the piston; but considerable resistance is offered to any sudden movement. Another form consists of a cylinder with an air-tight piston. As the latter moves, air can enter or leave the cylinder through a very small opening. A sudden movement is thus prevented by the change of pressure which is produced inside the cylinder. It is often applied to form an air cushion to reduce the shock or throw in a reciprocating motion; *e.g.* the bed of a printing press at the end of its travel.

Dash Wheel (*Chem. Eng.*) A washing or rinsing wheel used in washing textiles.

Date (*Botany*). The fruits of the date palm, *Phœnix dactylifera* (order, *Palmæ*), form the principal food of the Arabs of Northern Africa. The leaf stalks are used for cordage, mats, and baskets.

Datholite (*Min.*) A basic calcium and boron orthosilicate, $H_2O \cdot 2CaO \cdot B_2O_3 \cdot 2SiO_2$. Monosymmetric: occurring in glassy crystals, usually in veins in basic volcanic rocks. It sometimes alters to chalcedony, giving the pseudomorphous HAYTORITE. From Norway, Scotland, and the United States.

Datum Level *or* **Line** (*Surveying*). A line or level from which heights are calculated and measured. *See also* CONTOUR.

Daturine (*Chem.*) Another name for HYOSCYAMINE (*q.v.*)

Daub (*Paint.*) To paint carelessly, without taste or feeling, thus producing an inharmonious whole very offensive to the artistic eye.

Daucus (*Botany*). *Daucus carota* (order, *Umbelliferæ*). The well-known vegetable, the carrot, is a garden variety of the wild form. A medicinal volatile oil is extracted from the seeds in India.

Day (*Mining*). Parts of the workings near the surface where light can reach.

Daylight Loading (*Photo.*) A method of charging a hand camera with films by having the latter wound on a spool in contact with a strip of black paper. The latter is longer than the roll of film, and forms several turns round the outside of the spool. The end of the black paper is first detached and made fast to a roller in the camera. The latter is then closed and the roller turned, drawing the black paper along until the film attached to it is in the position to receive the image. The method has been worked out with great simplicity and ingenuity by the Kodak Company. Flat films are also made up into sets, like a pack of cards, and can be placed in cameras fitted with a suitable slide without the use of a darkroom.

Day Roll (*Photo.*) A name applied to the spool used in daylight loading of cameras. The sensitive emulsion is on a flexible film of length sufficient for a number of exposures (commonly twelve). The film is laid face upward on a strip of opaque black paper, longer than itself, and the two are wound together on a spool. The free end of the film is made fast to the paper, and the latter forms several turns round the outside of the spool to exclude light. *See* DAYLIGHT LOADING.

Day, Sidereal (*Astron.*) The period of a complete revolution of the stars, relative to the meridian. Its length is about four minutes less than the ordinary day. It is absolutely constant in duration.

"Day" Theory (*Music*). That advanced by Alfred Day, M.D. Important points: All chords derived from three roots, *viz.* Tonic, Dominant, and Supertonic. The building up of chords by 3rds to 9ths, 11ths, and 13ths. The division of Diatonic and Chromatic styles. The "Added 6th" is the 3rd inversion of the Dominant 11th. The "Sharpened 5th" is the Dominant 13th resolved upwards. The "Augmented 6th" derived from Dominant and Supertonic roots.

Day Work (*Various Trades*). Work paid for by the day instead of by the piece.

Deacon's Process (*Chem.*) A method of preparing chlorine on the large scale for the preparation of bleaching powder (*q.v.*) or any other purpose. Hydrochloric acid gas and air are passed over a heated porous surface (broken bricks) impregnated with copper sulphate. Excess of hydrochloric acid is removed by water, and for making bleaching powder the gas must be dried by passing through sulphuric acid.

Dead (*Eng., Build., etc.*) A term applied to materials of many kinds when they have lost some of their important or characteristic properties.

Dead Axle (*Eng.*) (1) An axle which does not rotate; (2) one which does not communicate motion to wheels, etc., but simply turns with them.

Dead Beat (*Clocks*). The "Graham" clock escapement in which the escape wheel, as soon as the drop has taken place, remains absolutely at rest ("dead"), thus distinguishing it from the older form of "recoil" escapement.

Dead Blow (*Eng.*) A blow struck without any spring or rebound.

Dead Burnt. A term applied to lime which has become vitrified by fusion of calcium silicate in the limekiln. It prevents proper slaking.

Dead Centre Lathe (*Eng., etc.*) A small lathe in which work is supported between two fixed or dead centres; motion is communicated to the work by a pulley or some other device fixed to it. Much used by watch and clock makers.

Dead Centres (*Eng.*) (1) Supporting points of a lathe, etc., which do not rotate. The back centre of a common lathe is often called a dead centre. *See also* DEAD CENTRE LATHE. (2) Also applied to the DEAD POINTS (*q.v.*) of an engine.

Dead, Disposal of the. *See* SANITATION.

Dead Eye (*Eng.*) A bearing in which the shaft runs in a hole bored through a single piece of metal, instead of in split BRASSES (*q.v.*)

Dead Ground (*Mining*). Parts of the vein or lode without ore, composed of GANGUE (*q.v.*)

Dead Head (*Eng.*) (1) The DEAD CENTRE of a lathe (*q.v.*) (2) A mass of metal filling a cavity at the head or top of a runner or pouring hole in a mould. The dead head is connected with the casting by the core of metal filling the hole or runner. The head and connecting metal are broken off when the casting is cold.

Dead Load Safety Valve (*Eng.*) A SAFETY VALVE (*q.v.*) kept down by a simple weight on the top, without any lever being used, as in the ordinary form of safety valve.

Dead Melting (*Foundry*). Heating metal till it becomes perfectly fluid, *i.e.* to a temperature considerably above its melting point.

Dead Plate (*Eng.*) A plate inside a firebox, on which fresh fuel is first placed, in order to become heated before reaching the fire proper.

Dead Point (*Eng.*) The position of a crank when it cannot be turned by the motion of the piston rod—*i.e.* when the crank and piston rod lie in the same straight line. A single cylinder engine cannot start from the dead point, and the crank must be slightly turned before steam is admitted. The dead points are sometimes also termed DEAD CENTRES.

Deads (*Mining*). Rubbish not containing ore.

Dead Shore (*Carp.*) Timber placed in a vertical position to support a load which acts downward only, *i.e.* without any outward thrust.

Dead Smooth File (*Eng.*) The very finest file cut; it has eighty or ninety teeth per inch.

Dead Turns (*Elect. Eng.*) The electromotive force produced in a dynamo is generally represented as proportional to the number of revolutions per second. *See* DYNAMO. But as the speed is increased the E.M.F. does not increase in the same proportion, owing to internal effects; so that the actual number of revolutions is greater than the number theoretically required to produce the E.M.F. obtained, and the extra revolutions are termed DEAD TURNS. For example, if a dynamo give 100 volts at 500 revolutions, it should give 150 volts at 750 revolutions if the law of proportionality held good. It will probably be found that more revolutions are necessary to give the 150 volts; if the number be 800 there are 50 dead turns.

Dead Wall (*Build.*) A BLANK WALL, one not pierced by doors or windows.

Dead Water (*Eng.*) Water which does not come into contact with the effective heating surface of a boiler. The best types of boiler reduce this water to a minimum amount.

Dead Weight *or* **Load** (*Eng.*) A load which is constant in position and amount; the opposite of a LIVE LOAD (*q.v.*)

Dead Weight Safety Valve (*Eng.*) *See* DEAD LOAD SAFETY VALVE.

Deal. A general name for certain coniferous woods. *See* WOODS.

Deal Frame (*Carp., etc.*) A machine saw used for cutting DEALS (*q.v.*) into thinner boards; it usually carries several parallel saws of the reciprocating type

Deals (*Carp., etc.*) Sawn wood (deal) of size 9 in. × 3 in. or 12 in. × 3 in.

Dean (*Mining*). The extreme end of a working.

Death Rate (*Hygiene*). By a death rate is understood the ratio between the deaths and population. The formula for calculating this rate is:

$$\frac{\text{Number of deaths} \times 1{,}000}{\text{Population}}$$

Thus, supposing a town has a population of 85,000, and the number of deaths during the year was 1,125, then $\frac{1{,}125 \times 1{,}000}{85{,}000} = 13{\cdot}23$ per 1,000. To obtain a death rate for any one week, divide the estimated population by 52·17747, the result giving the weekly population. Thus $\frac{85{,}000}{52{\cdot}17747} = 1{,}629$. Supposing there are twenty-one deaths during one week, then the death rate per thousand is : $\frac{21 \times 1{,}000}{1{,}629} = 12{\cdot}89$.

Debruised (*Her.*) An expression used when an ordinary is placed upon a charge. But when the ordinary is placed upon another ordinary, the term "over all" or "surmounted by" takes its place: "debruised by" is not then used.

Decadence. A falling off from a better style. In art the term is used to denote the period after Raphael and Michael Angelo.

Decametre. *See* WEIGHTS AND MEASURES.

Decani (*Music*). That side of the choir on which the dean (decanus) sits. The opposite side to cantoris. The right side looking east.

Decarburisation (*Met.*) Removal of carbon from cast iron by the PUDDLING PROCESS (*q.v.*) or the BESSEMER PROCESS (*q.v.*)

Decastyle (*Architect.*) A term applied to a temple which has ten columns in the front row. *See* DISTYLE, TETRASTYLE, HEXASTYLE, *and* OCTASTYLE.

Deciduous (*Biology*). The term applied to those organs or parts which are shed periodically by a plant or animal; *e.g.* the leaves of the oak, ash, and the horns of most varieties of deer are deciduous.

Decimal. A fraction whose denominator is ten or a power of ten. It is written without the denominator, the numerator being preceded by a dot, the DECIMAL POINT, written on the left-hand side of the figure: thus $155{\cdot}65 = 155\frac{65}{100}$.

Decimal Gauge (*Eng., etc.*) A gauge divided into decimals of an inch, instead of the ordinary fractions, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, etc.

Decimal Point. *See* DECIMAL.

Decimal Threads *or* **Pitches.** *See* SCREW THREADS.

Decimetre. *See* WEIGHTS AND MEASURES.

Decimo Sexto (*Print.*) The size of a sheet of paper after being folded to form sixteen leaves. Usually called SIXTEENMO and written 16mo.

Deciso (*Music*). Decided.

Deck Crane. A crane fixed on the deck of a ship for loading purposes; frequently driven by a steam winch supplied from the main boilers.

Deckle (*Paper Manufac.*) (1) A movable wooden frame which fits over a wire mould, used in the manufacture of paper by hand. (2) The rough or irregular edge of handmade paper. The two uneven edges of a Bank of England note are examples.

Deckle Straps (*Paper Manufac.*) Endless rubber bands which run on the machine wire to keep the wet pulp in its proper position, and regulate the width of the paper.

Declination (*Astron.*) The angular distance of a star above the horizon, measured along a vertical circle. Abbreviated to DECL. The vertical great circle through the star and the celestial pole is termed the DECLINATION CIRCLE.

Declination Circle (*Astron.*) *See* DECLINATION.

Declination, Magnetic. The horizontal angle between the axis of a freely suspended magnetic needle and the true geographical meridian. This varies at different points on the earth's surface, and is also slowly but constantly changing at any given point.

Decomposition of Light. *See* SPECTRUM, COLOUR, *etc.*

Decorated (*Architect.*) The name given to one of the periods of Gothic architecture. Architecture in England can be divided into the following styles, but it must be noted that the transition from one style to another was very gradual.

	A.D.
ANGLO-SAXON	449—1066.
NORMAN .	1066—1175 (Early, 1066—1125. Late, 1125—1175).
TRANSITION .	1175—1189.
EARLY ENGLISH	1189—1307.
DECORATED .	1307—1377.
PERPENDICULAR	1377—1547.

The following are some of the characteristics of the Decorated style: (1) The extensive use of scroll and wave mouldings. Strong contrasts of light and shade common in Early English mouldings are avoided. (2) The ball flower. (3) Geometrical, Reticulated, Flowing, and Flamboyant window tracery. (4) Foliage less conventional than in the other periods of Gothic architecture. (5) Detached shafts as used in Early English pillars are abandoned. *See* CURVILINEAR *and* FLAMBOYANT.

Decorticating. (1) A process carried out by cutting or pulverising machines which assist the separation of the husks and linters from the oily kernels of cotton seed, linseed, or castor beans prior to pressing. Special machines are made for arachis and cocoanuts. (2) A similar result is obtained chemically by acting on cotton seed with a mixture of nitrous anhydride and sulphur dioxide gases in the presence of enough air to reoxidise the reduced nitrogen compounds. A few seconds suffice to destroy the structure of the husks, which crumble to a fine powder with the slightest friction.

Decrescendo (*Music*). Decreasing in loudness. Abbreviation, DECRES or >.

Deep Sea Deposits (*Geol.*) Strata which have been formed at great depths below the surface of the ocean. These are primarily divisible into (1) TERRIGENOUS, which consist of materials mostly derived from the waste of adjacent lands, and (2) THALASSIC, which are due more or less directly to organic or organico-chemical causes. To the former belong blue muds, coral mud, glauconite, and some others; to the latter, foraminiferal ooze, diatom ooze, radiolarian ooze, and the red clays, which occur with the last named deposit. These are partly of chemical origin.

Deep Well Water (*Hygiene*). Deep wells supply many towns with water. Borings are made to a considerable depth, penetrating the upper impermeable strata, until the water-bearing stratum is reached. Water obtained from this source is usually hard, but very palatable and wholesome. *See* ARTESIAN WELLS.

Deer (*Zoology*). A family (*Cervidæ*) of the great mammalian group of *Ungulates*. They are very widely distributed, being found in nearly every part of the world. The horns are confined to the male, and are shed annually, except in the case of the Reindeer. *See* HORN.

Deflection (*Eng., Build.*) Bending: deviation from an original position or direction, *e.g.* the sagging of a beam or girder at the centre when supported at both ends. *See* BEAMS.

—— (*Met.*) A test for steel rails, varied according to section and weight. Double headed 70 lb. to yard rails, supported between centres 3 ft. 6 in. apart, must not show (1) more than 3 in. deflection after two blows in the centre from a ton weight falling 18 ft.; (2) or $\frac{5}{8}$ in. deflection under a dead weight of 28 tons.

Deflector (*Eng.*) A general term for a plate or other object used to direct a stream of gas or a liquid in a particular direction: frequently used in furnaces and fireboxes to direct the hot gases along a certain path.

Deformation (*Phys., etc.*) A general term signifying an alteration in the shape of a body, whether permanent or not.

Degelatinising. The process of extracting gelatine or glue from bones. This may be done either wholly or partially: if the former, the residue is used wholly for manurial purposes (*see* MANURE); if the latter, the residue of the bones is calcined to form animal charcoal.

Degras. A fat or grease obtained during the manufacture of leather, particularly chamois leather. It is also obtained as a byproduct in various other trades. Degras is often made as a regular commercial article by oiling hides with cod oil, fermenting, fulling, and treating with potash. Degras in England is more commonly called SOD OIL, which is, strictly, the oil from curried leather in general, Degras being obtained from chamois leather only. Artificial Degras is made by adding tallow to cod oil (and sometimes red oil and wool grease), and incorporating with a neutral soap.

Degreasing. The process of extracting fat or grease from wool and bones by means of benzene or other solvent.

Degree. *See* WEIGHTS AND MEASURES.

—— (*Heat*). The unit in which difference of temperature is measured. *See* CENTIGRADE, FAHRENHEIT, *etc.*

—— (*Music*). Each step (line or space) of the stave.

Degrees of Freedom (*Phys.*) A body which is perfectly free has six possible varieties of motion, three motions of translation parallel to three axes which are mutually at right angles, and three motions of rotation about axes parallel to the same three axes of reference. These six varieties of motion are called the "Degrees of Freedom" of the body, and any one or more may be destroyed by introducing a suitable constraint. Thus a cube lying on a plane surface has two motions of translation and one of rotation, *i.e.* three degrees of freedom. A ring smoothly fitting a round rod has two degrees of freedom, one of translation along the rod and one of rotation round it; and a square ring or frame which fits exactly on a square rod has one degree of freedom, a motion of translation only.

—— (*Chem.*) *See* PHASE RULE.

Dehiscent Fruits (*Botany*). Fruits which open naturally to set free their seeds. They are usually called CAPSULES.

Del *or* **Delt** (*Art*). Short for the Latin word *delineavit, i.e.* has drawn. On an engraving, etc., it follows the name of the author or designer of the original drawing from which the reproduction has been made.

Dele (*Typog.*) *See* DELETE.

Delete (*Typog.*) To expunge, blot out, erase, or omit. Indicated in proofs thus, δ. *See also* PROOF CORRECTIONS.

Delft. The term Delft is now rather indiscriminately applied to all Faience with blue decoration upon a white ground; true Delft-Faience was first made at Delft, near Rotterdam, in Holland, about the beginning of the seventeenth century; it consisted of a yellowish earthenware paste covered with an opaque stanniferous glaze, the blue and other coloured decorations being superimposed. Large quantities of blue and white wares are still made at Delft.

Delicato (*Music*). With delicacy.

Deliming (*Leather Manufac.*) Removal of the lime from the skin previous to tanning. *See* LEATHER MANUFACTURE.

Deliquescence (*Chem.*) Certain solid substances have the power of absorbing moisture from the air and forming a solution therewith. Such substances are said to be deliquescent. Examples are calcium chloride, caustic soda and potash, ferric chloride.

Delivery (*Eng.*) The discharge of water, etc., by a pump. RATE OF DELIVERY is the usual expression for the amount of fluid pumped per minute.

—— (*Foundry*). The manner in which a pattern leaves the mould.

Delivery Pipe (*Eng.*) The pipe by which water flows from a pump.

Delta (*Geol.*) Fan-shaped areas composed of mud, sand, silt, gravel, etc., brought together by the action of rivers, and dropped at the parts where their velocity, and therefore their transporting power, is checked. Deltas usually occur at the junction of rivers and the waters of lakes or those of the sea; but they may also be formed at the foot of a slope upon the land.

Demi Brassards (*Armour*). Strips of metal which protected only half of the arm.

Demi Lion Rampant (*Her.*) A lion rampant cut off or couped midway, the upper part only appearing, including the forepaws and the tip of the tail.

Demisemiquaver (*Music*). *See* NOTES.

Demivol (*Her.*) One wing only displayed as a charge on a shield. It should be described as either dexter or sinister.

Demy (*Papers*). A size of paper. Printing demy measures $22\frac{1}{2} \times 17\frac{1}{2}$ in.; writing demy, $20 \times 15\frac{1}{2}$ in., and drawing demy, 22×17 in.

Den (*Chem. Eng.*) The reaction pit or chamber for the manufacture of superphosphates. Placed immediately under the mixers.

Dendritic Markings (*Geol.*) Accumulations of mineral matter, usually one of the hydrated oxides of manganese, less frequently hydrated oxide of iron, which have assumed a mosslike or treelike form in the course of their growth from aqueous solutions. Their resemblance to organic forms is purely accidental.

Denim (*Cotton Weaving*). A very heavy-warp twilled cloth composed of hard twisted warp and usually coarse cop weft. The warp is mostly composed of one colour.

Density (*Photo.*) A term used to describe the strength and vigour of a negative. A dense negative has the dark portions very strongly defined, and a gradual gradation to the most transparent parts; such a negative gives a good print, full of detail.

—— (*Phys., etc.*) The quantity of material or matter contained in unit volume. The specification of density, unlike specific gravity (*q.v.*), always requires the use of two units—one of volume, the other of mass. For example, density may be given in grams per cubic centimetre, grams per litre, pounds per cubic foot, tons per cubic yard, etc.

Density of Gases (*Phys., Chem.*) Conveniently quoted in grams per litre: the expression generally used in chemical books is really the specific density in terms of hydrogen: thus if the density of a gas is said to be 16, it is sixteen times as heavy as the same volume of hydrogen at the same pressure and temperature.

Density of Petrol (*Motor Cars*). *See* PETROL.

Density of Water (*Phys., etc.*) *See* WATER.

Dent (*Textile Manufac.*) A split or space in the reed or sley (*q.v.*)

Dentelle (*Binding*). A style of finishing (with very fine tools) delicate gilt designs to resemble lacework.

—— (*Lace Manufac.*) The French term for lace. A lace that is finished off with a toothed edge.

Denticulated Bed Mould (*Architect.*) A bed mould enriched with DENTILS (*q.v.*)

Dentils (*Architect.*) An ornament originally used in the bed-mouldings of the Ionic and Corinthian cornices. It consists of a series of rectangular blocks, the height of each block being about twice its width, and the width of the spaces between the blocks about one-third their height. *See* INTERDENTILS.

Dentine (*Zoology*). The bonelike substance of a tooth. It is covered by a very hard secretion—the ENAMEL.

Denudation (*Geol.*) A general term expressive of the results of various natural agencies in wasting or wearing away exposed surfaces of rocks. SUB-AËRIAL DENUDATION is that which is effected by rain, rivers, frost, and chemical action. GLACIAL DENUDATION is that arising from the erosive influence of stones carried forward by ice moving in contact with the surface of rocks. MARINE DENUDATION is that wrought by the action of the sea. The two chief agents which supply the motive power are solar energy on the one hand, and gravitation on the other.

——, **Rate of** (*Geol.*) Various estimates have been made, chiefly by Lyell, Croll, and Tylor, of the rate at which the materials composing the land are being stripped off and the level reduced to that of the sea. This is arrived at by estimating the quantity of material transported in suspension, in solution, and otherwise carried seaward per annum by some river, measuring the area drained by that river, and thus arriving at the total quantity removed from the whole surface of its basin in the period chosen. The rate varies within wide limits; but an average is usually taken at about one foot in three thousand years.

Deodar. *See* WOODS.

Deodorant (*Hygiene*). A substance which, by the oxidation of the products of decomposition, destroys or masks offensive odours. Among the common deodorants are charcoal, chloride of lime, dry earth.

Deoxidation (*Met.*) The REDUCTION (*q.v.*) of ores during smelting or by some preliminary process such as ROASTING (*q.v.*)

Dephlegmator (*Chem. Eng.*) A still-head or rectifying apparatus used in distilling spirits and other products with low boiling points. *See* FRACTIONAL DISTILLATION.

Dephosphorisation (*Met.*) Removal of phosphorus from iron by the BASIC PROCESS (*q.v.*)

Depickling (*Leather Manufac.*) Skins which are pickled with salt or acid for transport must be depickled before tanning. For this purpose whiting, salt, and other similar compounds are used.

Deposit. The term applied to the metallic coating obtained in electroplating.

Deposit (*Eng.*) Matter collected on boiler plates; also called INCRUSTATION (*q.v.*)

Deposition (*Geol.*) The correlative of denudation. Materials removed from areas exposed to the action of the various natural agents of waste are moved by running water, and are, sooner or later, left again in the solid form. The chief agents concerned in both processes are solar energy and gravitation, operating by means of water. As in the case of denudation, the rate of deposition varies within very wide limits. Deposition is the usual concomitant of depression of the surface, and is, of course, also dependent upon denudation.

Depression (*Meteorol.*) An area over which the barometric pressure is low, gradually diminishing from the edge of the area towards the centre.

Depression of Land (*Geol.*) Changes of level of the land, generally effected by undulatory movements of the Earth's crust, appear to have affected each part of the surface at one time or another. The wave-like movement slowly progresses from one part to another, and the upward phase, which gives rise to elevation of the land, is followed by the opposite or downward phase of the terrestrial undulation, whereby depression is produced. Deposition of sedimentary materials usually accompanies depression of the land.

Depression of the Freezing Point (*Heat*). *See* FREEZING POINT.

Depth (*Paint.*) The suggestion of subtle variety produced by sensitive management of gradations of tone. It is the converse of superficiality of tone quality, and is one of the sources of the pictorial mystery which gives to inspired works of art their special persuasiveness. The word is also used in association, *e.g.* depth of tone, to define the particular quality of a picture which is pitched in a low key.

Depth of Focus (*Photo.*) The power of a lens to produce a sharp image of objects which are at varying distances from the camera. It depends on the relation of the diameter of the STOP (*q.v.*) to the focal length of the lens.

Derby China. Porcelain was first made in Derby about 1750. The Derby Porcelain Works, however, were not established until 1756, under William Duesbury. It was continued by him, his son, and his grandson until the year 1815, when the business was sold to Robert Bloor, who carried it on until 1846, when it was finally closed. The most beautiful wares were produced at Derby at the end of the eighteenth century. Under Bloor they degenerated both in refinement and taste. The best period of Derby china was from about 1775 to 1800, during which time painting and gilding were brought to a high state of perfection. For MARKS, *see under* POTTERY AND PORCELAIN.

Derby Float. (*Plastering*). A long piece of board with a handle at each end. Used for "floating" large surfaces. *See also* FLOAT.

Derby Red (*Dec.*) A scarlet red pigment of good covering and staining power, sometimes used as a substitute for vermilion (*q.v.*) It is a basic chromate of lead, and is crystalline in structure. Called also CHINESE RED, CHROME RED, and AMERICAN VERMILION.

Derbyshire Spar (*Min.*) A popular synonym for FLUORSPAR (*q.v.*)

Derivative Rocks (*Geol.*) Are those which are composed of materials derived from some pre-existent rocks. It is usual to regard all massive eruptive rocks (as distinguished from those of pyroclastic origin) as being original. Conglomerates, sandstones, shales, and clays are good examples of derivative rocks. Limestones, coal seams, and several other types of rock may be regarded as either original or derivative.

Derived Fossils (*Geol.*) It frequently happens that, when a fossiliferous rock is undergoing waste at the surface, the fossils included in it are liberated, and are subsequently rearranged along with other materials in rocks of later date. Such fossils need to be distinguished from those which actually lived during the period when their matrix was laid down, and the above name is conveniently applied to them in consequence.

Derived Units (*Phys.*) All others than the fundamental units of time, length, and mass, *e.g.* the units of space, acceleration, force, etc.

Dermal Denticles (*Zoology*). The small toothlike scales on the skin of the sharks and dogfishes. These give the shagreen character to these fish skins.

Dermis (*Zoology*). The sub-epidermal layer of the skin, consisting of connective tissue containing capillaries and nerves.

Derrick. The pyramidical frame which carries the boring apparatus used in drilling oil wells. Sometimes called an oil "rig," which really comprises the complete drilling outfit. The frames are mostly open (like a colliery headgear) in American oil fields, and boarded-in on European fields.

—— (*Build.*) A mast kept in position by guy ropes, and having a pulley fixed to it at the top, with a rope passing through to a windlass. Used for hoisting trusses, etc.

—— (*Eng.*) A form of crane (*q.v.*) with a hinged jib, which can be set at various angles: also applied to a system of poles used to support hoisting gear.

Derrick Barrel (*Eng.*) An auxiliary chain barrel in a crane on which the DERRICK CHAIN (*q.v.*) is coiled.

Derrick Chain (*Eng.*) The chain by which a hinged jib is raised or lowered. *See* CRANE.

Descending Letters (*Typog.*) Those letters having descending strokes, viz. *g*, *j*, *p*, *q*, and *y*.

Descriptive Astronomy. The science dealing with the motion and distances of the heavenly bodies.

Descroizilles Degrees. The French soapmakers' *titre* or standard for soda ash. The strength is expressed in terms of pure sulphuric acid (=49) neutralised by 100 parts of soda ash. The German standard is in terms of Na_2CO_3 (=53). The English standard (sometimes called GAY LUSSAC DEGREES) is the percentage of Na_2O (=31), or real alkali, which is generally displacing the old trade degree based on 64 instead of 62 as the molecular weight of Na_2O. Therefore pure soda ash = 31° English, 92·45° Descroizilles, and 100° German.

Desert (*Geol.*, *etc.*) Any part of the surface of the land where the conditions have long been unsuitable for the growth of vegetation. The usual meaning attached to the word, however, implies that deserts are only due to a small rainfall (generally under 10 in. per annum), which occurs at intervals too irregular to permit of the growth of any vegetation except such as is specially adapted to the conditions. They are not confined to the hotter regions of the globe; *e.g.* areas of drifting volcanic sand in Iceland form deserts.

Desiccating (*Carp.*, *etc.*) Artificial drying of timber by heat.

Desiccator (*Chem.*) Of various shapes, but consisting essentially of a closed vessel with a receptacle for calcium chloride, strong sulphuric acid, or other water absorbing substance, and a shelf to carry the article to be kept dry.

Design. Design in its relation to the fine and applied arts implies invention—the creation of something which had no previous existence in that particular form, and which is therefore original and new. But it is doubtful whether originality in its completest sense exists. It is not given to us to imagine anything beyond the limits of human experience, so that our creations are little more than recollections and modifications of things or forms already existing in nature. The fabulous beings imagined by the ancients—the centaur, the satyr, the cyclops, the mermaid are cases in point; they are not inventions, but combinations of existing material. In the domain of the fine arts, for the production of a picture, a statue, or a cathedral, design plays an important part, since the proportions, the proper balancing of units, must be carefully considered. It is, however, in the so-called lesser arts or crafts that design in the more usual acceptation of the term is brought into play. This is called APPLIED DESIGN. It consists of the application of beautiful forms and colours to a particular object or purpose, such as a stained glass window, a wallpaper, a piece of jewellery, or to the various articles of daily use. The application of design has been practised during all ages, from the time of primeval man: by the cave dwellers, who traced designs and fancies upon bones, shells, and the walls of their caves; by the savage tribes, who decorated their canoes, their weapons of warfare, and even their own persons. The fundamental laws governing ornamental design, such as radiation, tangential junction, symmetry, balance, etc., are direct expressions of natural principles or facts: that of radiation in the sun's rays, the digits of the human hand, in starfish, etc.; that of tangential junction in plant and tree growth, the springing of branches from a parent stem. Even the various ornamental motifs, *e.g.* the circle, may be seen exemplified in the sun, the full moon, and the contours of various flowers, the spiral in serpents, in the convolutions of shells, and the tresses of human hair. Applied design, together with the rest of the fine arts, has always reached its highest development at the time of a nation's fullest growth, and to trace the history of a nation's art is to follow the growth of its civilisation. In the case of Egypt, the Cradle of the Arts, their civilisation had already reached its highest development at the time when the story of her existing monuments begin, all

authorities agreeing that the further we go back in Egyptian history, as told by her monuments, the finer the art. The long story of Egyptian art is therefore one of gradual and slow, but no less sure, decline, but a decline from a very high level of past attainment. From Egypt the centre of civilisation was transferred to Athens, and then to Rome, and from thence to Constantinople, the seat of the Byzantine Empire, which lasted practically to the birth of the mediæval period in the time of Charlemagne. In the thirteenth century architecture, which is properly the foundation of all the arts of design, was at its zenith. The so-called RENAISSANCE was a return to classic ideals. The GOTHIC style was slow to take root in Italy; it bloomed brilliantly, but only for a comparatively short season. The break up of the Renaissance came very suddenly, about the close of the sixteenth century; and from that time all the decorative arts slowly declined, until they reached their lowest ebb perhaps about the middle of the nineteenth century. From that time matters have gradually improved. In 1851 came the Great Exhibition, which, whatever its subsequent effect upon the decorative art of the country, at any rate showed us exactly where we were. It certainly was the means of opening our eyes to the wealth of design and splendour of colour of the art productions of our great dependency, India. During the latter half of the nineteenth century the most considerable figure in the decorative art world is unquestionably that of William Morris. It is not too much to say that it is mainly to the influence and inspiration of Morris that we owe the improvement which has taken place in our furniture, wallpapers, textiles, stained glass, embroidery, and latterly, since the founding of the Kelmscott Press, the decoration and printing of books. The art of William Morris was founded upon a study of the work of the twelfth, thirteenth, and fourteenth centuries. Broadly speaking, what Morris did in both practice and precept was to call the attention of his countrymen to the transcendent beauty of the old work and particularly the work of this period. His immediate followers, who dominate applied art teaching in this country at the present time, go a step further and say, "Go back to Nature, the original source of all art inspiration, but *study Nature in the light of the old work.*" NATURE STUDY is therefore the *note* of present day art teaching. All forms of eccentricity under the guise of originality are tabbooed, in the belief that true originality will in time be developed, and students are encouraged to study the forms of natural objects, and preferably the most familiar objects of plant and animal life, and at the same time to keep their attention fixed upon the finest productions of the past. To sum up the matter, the decorative arts have certainly touched the lowest possible ebb of commonness and vulgarity, and a distinct and marked improvement has taken place during the past thirty years. No great and lasting advance may, however, be expected, much less a return to the great times of art, except by a complete and systematic training of the worker, and a corresponding elevation of taste on the part of the public.

G. W. R.

Design (*Eng., etc.*) The calculation of the dimensions, and the drawing of the parts of a machine or structure.

Designer (*Arts*). (1) One who makes an artistic design to be afterwards more elaborately executed. (2) One who designs figures and patterns for the manufacturer.

Desilverisation. The process of freeing lead from silver before it is made into white lead, and to fit it for use in chemical works, by Pattinson's Process (*q.v.*) In the Parkes Process the argentiferous lead is melted in large iron pots, and molten zinc is added. The silver possesses a greater affinity for zinc than it does for lead, so that on cooling most of the silver separates from the lead and combines with the zinc.

Dessue *or* **Dizzue** (*Mining*). Cutting out a thin lode in its entirety; also undermining or laying bare a lode. The term is chiefly used in Cornish mines.

Destructive Distillation (*Chem.*) *See* DISTILLATION.

Detachable (*Cycles*). Any part of a cycle which can be easily removed and replaced by the rider without any tools other than those carried in the valise may be termed detachable.

Detail *or* **Details** (*Fine Arts*). Particular and subordinate parts of a work of art or building, as distinguished from the larger parts or the general conception.

—— (*Architect*). Drawings generally intended for the use of workmen, *i.e.* WORKING DRAWINGS.

—— (*Photo.*) The smaller or the less visible parts of a picture, which are only to be seen in a well made negative.

Detent (*Watches, Clocks*). (1) In a chronometer escapement the delicate spring carrying the locking stone. (2) In a fusee watch or clock, or in a weight clock, the detainer of the maintaining ratchet, the object of which is to prevent the stopping of a timepiece while it is being wound.

Detrition (*Geol.*) A term generally restricted to the reduction in size of rock fragments by causes of a mechanical nature.

Deuterozoic Rocks (*Geol.*) The group of rocks comprising the DEVONIAN ROCKS, OLD RED SANDSTONE, and CARBONIFEROUS SYSTEM.

Developable Surface (*Eng., etc.*) *See* DEVELOPMENT.

Developed Winding (*Elect. Eng.*) A diagram showing the windings of an armature and their connections as they would appear if they were removed from the iron core and spread out on a flat surface.

Developer (*Photo.*) A substance which renders the LATENT IMAGE (*q.v.*) visible. Developers act by reduction (*q.v.*) of the salts of silver in the film: most of them are organic substances. *See* PYROGALLIC ACID, HYDROQUINONE, EIKONOGEN, ORTOL, *etc.*

Development (*Geometry, Eng., etc.*) (1) Giving full details of some part of a piece of work. (2) Drawing out on a flat surface the exact shape of a sheet of metal, etc., which is to be hammered or bent into some required shape. Only certain shapes can be drawn out thus; these are termed DEVELOPABLE SURFACES. Solids which are bounded by flat faces, cones, and cylinders are such surfaces; a sphere is not.

—— (*Music*). The working out of "subjects" in classical music; that part in sonata form following the double bar.

—— (*Photo.*) The production of a visible image on a sensitive film, which has been exposed or acted on by light. The process is one of REDUCTION (*q.v.*), metallic silver being produced in a very fine state of division in the case of ACID DEVELOPMENT, and

deposited on nuclei formed of silver sub-iodide (Ag_2I) or sub bromide (Ag_2Br). In ALKALINE DEVELOPMENT the image is formed by the reduction of the sub-salt itself to metallic silver. As these sub-salts are only formed in the parts acted on by light, it follows that these parts will become dense and opaque by the deposition in them of the particles of metallic silver. The more intense the action of the light, the more silver sub-iodide, etc., is formed, and hence there will be a gradation of light and shade in the picture. *See also* DEVELOPERS.

Development, Acid (*Photo.*) Development (*q.v.*) in which an acid (*e.g.* acetic acid) is added for the purpose of controlling the process, which would otherwise be too violent, and would result in the darkening of the whole plate.

——, Alkaline (*Photo.*) The use of an alkali, *e.g.* ammonia or soda, along with pyrogallic acid (or some equivalent reducing agent). The alkali greatly increases the affinity of the body for oxygen, upon which the developing action depends. In many cases this action would be barely visible if pyrogallic acid were used alone.

Deviation (*Phys.*) In optics the angle through which a ray of light is bent by a prism, lens, etc. *See also* MINIMUM DEVIATION.

——, Magnetic. The error of a compass which is due to the magnetic effect of an iron ship or of iron fittings in a wooden ship.

Device (*Her., etc.*) (1) An emblem or design representing a family, person, or quality; usually accompanied by a motto. Used in heraldry (an heraldic bearing, cognisance, etc.); also in painting and sculpture. (2) A motto or legend used in place of such a design. *See* ARMORIAL BEARINGS.

Devil (*Foundry*). A small portable grate containing a charcoal fire, used for drying the internal surfaces of a mould.

—— (*Paper Manufac.*) A machine used in the manufacture of paper for removing dust and dirt from rags.

—— (*Plumb.*) A plumber's firepot: used for heating solder, etc.

Devitrification (*Geol., etc.*) All substances of a vitreous or glassy character tend with lapse of time to undergo molecular rearrangement. Glass of Roman age, once more or less transparent, is now turbid, in consequence of such changes. The stained glass of mediæval age in many of our cathedrals (York, for instance) has become granular and brittle through devitrification. In Nature the process plays an important part, especially in connection with eruptive rocks which were at one time vitreous, and have become stony or lithoidal through this cause.

Devonian System (*Geol.*) The group of rocks of marine origin, typically developed in Devonshire, which were formed in the long interval between the close of the Silurian period and the commencement of the Carboniferous. The fossils have a facies intermediate in character between those of the two named. In Scotland and the north of England occur other types of rocks (the OLD RED SANDSTONES), chiefly formed under Continental conditions contemporaneously with the marine Devonian rocks.

Devonshire Lace. A local definition. It has no decided characteristics, the workers being clever at copying almost any style of lace that may be in demand.

Dew (*Meteorol., Phys.*) Moisture deposited from the atmosphere on a cool surface by a process of gradual condensation. The cold surface lowers the temperature of the air in contact with it until any water vapour in this air falls to the temperature at which it condenses.

Dewing (*Woollen Manufac.*) The process of damping the cloth, either to prepare it for raising or to improve its handle.

Dew Point (*Phys., etc.*) The temperature at which moist air becomes saturated and begins to deposit its moisture, thus forming dew.

Dexter (*Her.*) The right hand side of the shield, but opposite to the left hand of the spectator from the front.

Dextrine *or* **British Gum** (*Chem.*) $(C_6H_{10}O_5)_n$. A white solid; soluble in water; insoluble in absolute alcohol; dextrorotatory; does not reduce Fehling's solution when pure; gives no colour with iodine; its solution heated with acids yields maltose and then glucose (dextrose). The pure substance is made by the action of malt extract on starch paste at about 60°; after filtering, maltose is precipitated by repeated treatment with alcohol, and finally the dextrine is thrown out by adding sufficient absolute alcohol. Commercial dextrines, which are always impure, are made by heating starch or by acting on starch with dilute sulphuric acid for a short time only; the acid is then precipitated with chalk, the clear liquid drawn off, and the residue pressed; the whole of the clear liquid is then concentrated in vacuum pans. As dextrine is a strong adhesive material, it is used for gumming envelopes, labels, and papers, finishing and thickening cotton, lace, etc., and is also sometimes used as a binder in making watercolours (*q.v.*) Dextrine required for commercial use should be free from acidity, dissolve almost wholly in cold water, and yield a solution of a light brown or yellowish colour.

Dextrorotatory (*Phys., Chem.*) A compound is said to be dextrorotatory when it has the power of rotating the plane of polarisation of light to the right *See* POLARISED LIGHT. If the substance is a solid, it is examined in solution in a suitable inactive solvent. *See* ASYMMETRIC CARBON ATOM.

Dextrose, Glucose, Grape Sugar (*Chem.*), $CH_2OH.(CHOH)_4.CHO$. A white crystalline solid, anhydrous when crystallised from strong alcohol, containing one molecule of water when crystallised from water; the anhydrous solid melts at 146°. It is dextrorotatory, and the freshly made solution rotates the plane of polarisation about twice as strongly as a solution which has stood for some time (bi-rotation); it is less sweet than cane sugar. Dextrose is readily soluble in water; alcohol diminishes its solubility, and anhydrous dextrose is insoluble in absolute alcohol. It occurs in honey and many sweet fruits, always along with lævulose (*q.v.*); also very largely in the urine in diabetes mellitus. In combination it occurs in the important class of substances called GLUCOSIDES (*q.v.*) Dextrose may be prepared by inverting a solution of cane sugar (that is, converting it into dextrose and lævulose) by the action of yeast or dilute sulphuric acid (after inversion the acid must be removed by baryta water), evaporating the solution to crystallising point under reduced pressure, washing the crystals with rectified spirit, and then crystallising from the same till pure. The commercial glucose which is used in making beer, sweets, jams, etc., contains dextrine, and is made by the action of dilute sulphuric acid on various kinds of starch. Dextrose has been synthesised Formal-

dehyde (CH_2O), acrolein dibromide (CH_2Br . $CHBr$. CHO), and glycerose, a mixture of the ketone and aldehyde of glycerine (*q.v.*), all undergo condensation to *a*-acrose, which is inactive lævulose. This yields on reduction inactive mannitol, from which inactive mannonic acid (or its lactone) can be obtained by oxidation. Inactive mannonic acid can be resolved by strychnine into the dextro- and lævo-acids. The dextro-acid, when heated to 150° with quinoline, is partially changed to *d*-gluconic acid (a stereoisomeride), which on reduction yields glucose. The following are important reactions of glucose: it reduces Fehling's solution and also ammoniacal silver nitrate; ferments with yeast, giving alcohol and carbon dioxide as chief products; unites with CaO, BaO, SrO, forming $C_6H_{12}O_6CaO$, etc. Carefully oxidised, it yields the monocarboxylic acid gluconic acid, CH_2OH . $(CHOH)_4COOH$. More strongly oxidised, saccharic acid is obtained, $COOH(CHOH)_4COOH$. Like aldehydes generally, it unites with hydrocyanic acid, with hydroxylamine, and with phenylhydrazine, forming cyanhydrins, oximes, and hydrazones respectively. With two molecules of phenylhydrazine, the very important glucosazone

$$CH_2OH(CHOH)_3 . C . CH : N . NHC_6H_5 \atop {\quad\quad\quad\quad\quad\quad\quad\quad :\atop N . NHC_6H_5}$$

is formed. *See* LÆVULOSE *and* OSAZONES. The formation of this substance serves as a test for glucose. As glucose is a pentahydric alcohol, it has the power of forming esters with acids; thus it forms a penta-acetate. On reduction, glucose yields SORBITOL, a hexahydric alcohol stereoisomeric with mannitol.

Dextrotartaric Acid (*Chem.*) Ordinary TARTARIC ACID (*q.v.*)

Dhoolie (*Cotton Weaving*). (1) A calico cloth with various bright coloured threads near the selvedges, forming a border. Sometimes a figured border is put in and called FIGURED DHOOLIE. Mostly for export to India. (2) The name of the loin cloth worn by Hindus.

Dhurra (*Botany*). *Sorghum vulgare* (order, *Gramineæ*). A cereal grown in Southern Europe, Egypt, and India, under the name of dhurra or dari, great millet, or guinea corn.

Di (*Chem.*) Symbol for DIDYMIUM (*q.v.*)

Diabase (*Geol.*) A name applied in very different senses by different writers to rocks allied in composition and structure to dolerite (*q.v.*) It is impossible to give an exact definition which would be generally accepted. On the Continent the term is usually applied to a basic eruptive rock (usually a dolerite) which is of pre-tertiary age.

Diadem. A CROWN (*q.v.*) (1) Anciently a band or fillet, either plain or adorned with jewels, worn as a badge of royalty, especially by Oriental sovereigns. It was made of linen, cloth, or silk, generally white in colour, and passed round the forehead, the ends being tied behind, and falling on the neck. (2) The aureola or crown of a martyr.

—— (*Her.*) One of the arches rising from the rim of a crown (or coronet) and supporting the mound and cross. *See* DIADUMENUS.

Diadumenus, a (*Sculp.*) The name given to statues in which the figure has a fillet or diadem (*q.v.*) bound round the head. The name was given to a celebrated statue by Polycletus.

Diagonal (*Geometry*). A line drawn between opposite corners of a geometrical figure.

Diagonal (*Eng.*) A BRACE or STRUT (*q.v.*) running diagonally across the openings of a built up girder or other framed structure.

—— (*Textile Manufac.*) A type of woven design of the twilled character.

Diagonal Bond (*Build.*) Bricks laid diagonally in the interior of thick walls.

Diagonal Winch (*Eng.*) A STEAM WINCH (*q.v.*) in which the cylinders are fixed at an angle with the base plate. This arrangement takes much less room than a horizontal one, and is much more rigid than a vertical engine.

Diagram. (1) An illustration or drawing which represents some part of an object, or illustrates some principle. (2) An INDICATOR DIAGRAM. Also a figure or drawing for the purpose of demonstrating the properties of any geometrical figure, as a triangle, circle, etc.; any illustrative figure, etc.

Diagraph. An optical instrument used for drawing, mechanically, projections of objects, maps, etc., on a scale proportionate to the distance of the instrument from the object. It consists of a glass, to which is attached a pencil governed by cords. The operator looking through the glass follows the lines of the object to be delineated, and as he moves the glass the pencil also moves and reproduces it.

Dial. (1) In general a disc or plate on which graduations are marked; these graduations enable the position of some form of pointer or index to be read off. (2) A MINER'S DIAL (*q.v.*)

Diallage (*Min.*) A clear green monosymmetric pyroxene occurring in serpentine and in some Gabbros (*q.v.*) It is a variety of Augite which has undergone some change arising from the action of subterranean waters. *See* PYROXENE.

Dialling *or* **Latching** (*Surveying*). Local terms for mine surveying.

Dialogite (*Min.*) Manganese carbonate, $MnCO_3$. In rhombohedral crystals, often rose red (hence the synonym RHODOCHROISITE); also yellow or brown; also massive and incrusting. Dissolves in warm hydrochloric acid. From Shropshire, Warwickshire, Ireland, Saxony, Hungary, North America.

Dialysed Iron (*Chem.*) Ferric hydroxide dissolves in a solution of ferric chloride. If such a solution be placed in a dialyser (a glass vessel open at the top and bottom: for use as a dialyser the bottom is covered with parchment and the vessel floated on water, the liquid to be dialysed being placed in the vessel), the solution forms hydrochloric acid, and a solution of ferric hydroxide remains on the dialyser. This is called dialysed iron; it is used in medicine where other iron preparations are unsuitable.

Dialysis (*Chem.*) Certain substances, such as albumin, gelatine, silicic acid, etc., having very high molecular weights when in solution in water, will not pass through a membrane such as bladder or parchment when the latter is floated on water; while most crystalline soluble substances will do so. The process of separating, by the use of such a membrane, a mixture of substances of the first class from substances of the second class is called DIALYSIS. For an example, *see* DIALYSED IRON.

Diamagnetism (*Phys.*) Substances whose magnetic permeability is less than unity (*i.e.* less than that of air), or whose magnetic susceptibility is negative, are said to be diamagnetic. Unlike paramagnetic substances such as iron, they tend, in a

magnetic field, to set themselves so that as few lines of force as possible pass through them, and hence are repelled by a magnet pole.

Diameter. (1) The line drawn across a figure; usually a line drawn through its centre. (2) The length of such a line.

Diameter of Commutation (*Elect. Eng.*) A diameter of a commutator drawn through the points of contact of the brushes.

Diameter Theory (*Textile Manufac.*) The theory of setting the cloths, based on the diameter of the threads and the number of intersections of warp and weft in a repeat of the weave.

Diametral Pitch (*Eng.*). The number of teeth on a spur wheel divided by the diameter of the PITCH CIRCLE (*q.v.*)

Diamidoazobenzene (*Chem.*) CHRYSOIDINE (*q.v.*)

Diamines (*Chem.*) When one atom of hydrogen from both of two molecules of ammonia is replaced by a divalent radical, the resulting compound is called a diamine; *e.g.* ethylene diamine is $N\begin{cases} CH_2 . CH_2 \\ H \quad\quad\; H \\ H \quad\quad\; H \end{cases}N$ and metaphenylene diamine is $C_6H_4\begin{cases} NH_2 \\ NH_2 \end{cases}$ (1 : 3). The PTOMAINES, PUTRESCINE, and CADAVERINE (*q.v.*) are diamines.

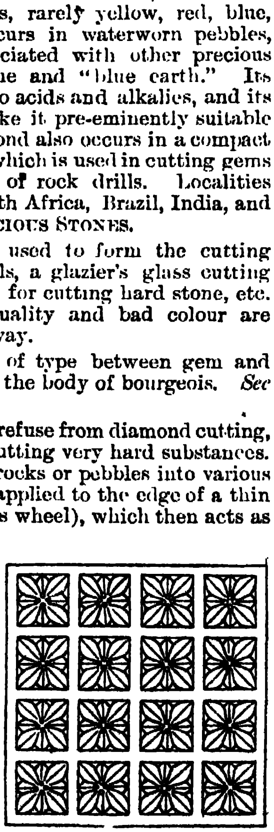
Diamond (*Min.*) Carbon in its cubic form (*cf.* GRAPHITE). Occurs in octahedra, often with curved faces. Colourless, rarely yellow, red, blue, or black. It often occurs in waterworn pebbles, in alluvial deposits associated with other precious stones, and in sandstone and "blue earth." Its hardness, its resistance to acids and alkalies, and its high refractive index make it pre-eminently suitable for use as a gem. Diamond also occurs in a compact variety known as BORT, which is used in cutting gems and to arm the crowns of rock drills. Localities for the diamond are South Africa, Brazil, India, and Australia. *See also* PRECIOUS STONES.

—— (*Trades*). Often used to form the cutting point of a tool, *e.g.* drills, a glazier's glass cutting tool, some forms of saws for cutting hard stone, etc. Diamonds of inferior quality and bad colour are generally used in this way.

—— (*Typog.*) A size of type between gem and pearl, and equal to half the body of bourgeois. *See* TYPE.

Diamond Dust. Fine refuse from diamond cutting, used for grinding and cutting very hard substances. For example, in cutting rocks or pebbles into various shapes, diamond dust is applied to the edge of a thin rotating disc (a lapidary's wheel), which then acts as a fine saw.

Dianella Tasmanica (*Botany*). Order, *Liliaceæ*. The "Broad Leaved Flax Lily" of Tasmania and Australia yields a good fibre for papermaking, and is easily grown.



DIAPER (*Architect.*)

Diaper (*Architect.*) A surface ornament, either carved or painted, usually repeated in squares, and applied to the face of a wall. It was extensively used in England during the EARLY ENGLISH and DECORATED periods.

Diaper (*Her.*) A surface decoration of a shield used only as an ornament. It must not be considered as a charge.

—— (*Textiles*). A class of cloth in which the design is formed by alternate squares or lines of warp and weft face, and which is reversible. The old DIAPERS or DORNICS were usually of a damboard or dice pattern, and were used for coarse table-cloths; but now diapers are mostly of the bird's-eye or small diamond pattern, and are used for many purposes, such as children's bibs, towellings, dusters, etc. The name "Dornick" is derived from Tournay, in France. Synonymous terms, DICED, DIMITY.

Diaphaneity. The property of transmitting light. When a substance possesses perfect diaphaneity, it is said to be TRANSPARENT; when it transmits some light, but is not clear enough to allow objects to be seen through it, it is said to be TRANSLUCENT. When no light can pass, it is OPAQUE.

Diaphragm. A general name for a partition across a space or cavity.

—— (*Photo.*) A partition with a circular opening placed in or near the lens to reduce the diameter of the pencil of rays passing through it. A small opening increases the sharpness of the image, but diminishes the intensity of illumination of the plate, and therefore necessitates a longer exposure.

—— (*Zoology*). The partition between the thorax and abdomen in a mammal.

Diastase *or* **Amylase** (*Chem.*) An ENZYME (*q.v.*) of unknown composition; it contains carbon, hydrogen, nitrogen, oxygen, sulphur, and ash. It can be obtained from malt in a variety of ways; *e.g.* the malt is treated with alcohol, the residue is extracted with glycerine, and the glycerine solution is precipitated with a mixture of alcohol and ether. The precipitate is dissolved in water, and once more precipitated by alcohol. Diastase is a yellowish-white amorphous powder. Diastase (or substances closely allied to it in properties) is extremely wide-spread in nature, occurring in plants and animals; *e.g.* the so-called PTYALIN of the saliva is a diastase. The chief property of diastase is its power of converting starch into dextrine and the sugar maltose. The most favourable temperature for its action is about 54°: it is destroyed (when in solution) at 75°. Diastase is the most important constituent of MALT EXTRACT, but many preparations, on account of the high temperature employed in their manufacture, contain no diastase. *See also* ENZYMES.

Diastyle (*Architect.*) The name given to the spacing of the columns in a Grecian temple when the space between the columns is equal to three times the lower diameter of the shaft. *See* ARÆOSTYLE, PYCNOSTYLE, SYSTYLE, EUSTYLE, *and* INTERCOLUMNIATION.

Diathermanous (*Phys.*) Substances which are transparent to radiant heat are said to be Diathermanous (*e.g.* rocksalt).

Diatom (*Biology*). *Diatomaceæ*, a class of very minute unicellular plants (*Algæ*) found in fresh and salt water. Their silicified valves occur as fossils, and form the deposits known as DIATOM EARTH.

Diatom Earth. Accumulations of the siliceous cases or frustules of the minute and lowly form of vegetable life known as diatoms. The "earth" in most cases has gradually accumulated on the bottom

of fresh water lakes. It has a considerable commercial value, and under the name of DIATOMITE is largely employed in the manufacture of dynamite. *Also termed* KIESELGUHR *and* MOUNTAIN MEAL.

Diatomic Molecule (*Chem.*) A molecule of an element containing two atoms. Thus the molecules of hydrogen, oxygen, nitrogen, and chlorine are each believed to consist of two atoms of the respective elements.

Diatonic (*Music*). Consisting chiefly of tones, as opposed to chromatic. Melody is formed wholly on the diatonic scale.

Diatonic Scale (*Sound*). A series of notes whose frequencies are proportional to the quantities

$$1,\ \tfrac{9}{8},\ \tfrac{5}{4},\ \tfrac{4}{3},\ \tfrac{3}{2},\ \tfrac{5}{3},\ \tfrac{15}{8},\ 2.$$

This gives a succession of the following intervals: Tone, Tone, Semitone, Tone, Tone, Tone, Semitone.

Diazoamidobenzene (*Chem.*) *See* DIAZO REACTIONS.

Diazomethane (*Chem.*), $\mathrm{CH_2}\left<\begin{array}{c}\mathrm{N}\\ \|\\ \mathrm{N}\end{array}\right.$. A yellow gas; no smell; poisonous; attacks the eyes and skin. Water decomposes it, forming methyl alcohol; acids give the corresponding methyl ester. It is obtained by the action of alkalis upon nitrosomethyl urethane:

$$\mathrm{CO}\left<\begin{array}{l}\mathrm{N\,.\,CH_3}\\ \ \ |\\ \ \ \mathrm{NO}\\ \mathrm{OC_2H_5}\end{array}\right. + \mathrm{HONa} = \mathrm{CO}\left<\begin{array}{l}\mathrm{ONa}\\ \mathrm{OC_2H_5}\end{array}\right. + \mathrm{H_2O} + \left.\begin{array}{c}\mathrm{N}\\ \|\\ \mathrm{N}\end{array}\right>\mathrm{CH_2}.$$

See URETHANES.

Diazonium Salts (*Chem.*) *See* DIAZO REACTIONS.

Diazo Reactions (*Chem.*) When an aromatic amine is converted into a salt and a solution of the salt treated with nitrous acid below 5°, a diazonium salt is produced. This process is called DIAZOTISING, and the reaction is called the DIAZO REACTION. For example, when one molecular proportion of aniline is dissolved in between two and three molecular proportions of hydrochloric acid diluted with water, a solution of aniline hydrochloride is formed, and one molecular proportion of the acid is left over. The solution is now cooled to 0°, and one molecular proportion of sodium nitrite in strong solution is gradually added; this, with the free acid, forms nitrous acid, which, with the aniline hydrochloride, forms the diazonium chloride

$$\mathrm{C_6H_5NH_2\,.\,HCl + ON\,.\,OH = C_6H_5\underset{\displaystyle Cl}{N}\!:\!N + 2H_2O}.$$

The diazonium salts are colourless, crystalline solids soluble in water and insoluble in ether; they are unstable, and some (*e.g.* the nitrate) are explosive. They are usually only prepared in solution, and their very great importance consists in the fact that they undergo many important reactions. The following are examples: (1) Warmed with alcohol, the group $\mathrm{N_2X}$ is replaced by hydrogen, *e.g.* $\mathrm{C_6H_2Br_3N_2Cl}$ gives $\mathrm{C_6H_3Br_3}$. (2) Boiled with water, they give phenols, *e.g.* $\mathrm{C_6H_4CH_3N_2Cl}$ gives $\mathrm{C_6H_4CH_3OH}$. (3) Heated with cuprous chloride, bromide, or cyanide, chloro, bromo, and cyanogen derivatives are formed, *e.g.* benzene diazonium chloride with cuprous cyanide gives PHENYL CYANIDE (BENZONITRITE), $\mathrm{C_6H_5CN}$. (4) Heated with potassium iodide, the diazonium sulphate gives an iodo compound, *e.g.* $\mathrm{C_6H_5N_2HSO_4}$ gives PHENYL IODIDE (IODOBENZENE), $\mathrm{C_6H_5I}$. (5) The diazonium bromides add on two atoms of bromine and form perbromides, *e.g.* $\mathrm{C_6H_5NBr\,.\,NBr_2}$: the latter compound with ammonia gives DIAZOBENZENEIMIDE, $\mathrm{C_6H_5\,.\,N}\left<\begin{array}{c}\mathrm{N}\\ \|\\ \mathrm{N}\end{array}\right.$, a liquid with stupefying odour. (6) Reduced with stannous chloride, benzene diazonium chloride gives PHENYLHYDRAZINE HYDROCHLORIDE, $\mathrm{C_6H_5\,.\,HN\,.\,NH_2HCl}$. (7) With aniline, benzene diazonium chloride forms DIAZOAMIDOBENZENE, $\mathrm{C_6H_5N:N\,.\,NHC_6H_5}$, a yellow crystalline solid which, when heated with aniline and aniline hydrochloride, is changed to the isomeric AMIDOAZOBENZENE, $\mathrm{C_6H_5\,.\,N:N\,.\,C_6H_5NH_2}$, a yellow crystalline solid: its disulphonic acid is a valuable dye—FAST YELLOW. A few fatty diazo compounds are known; thus DIAZOACETIC ESTER, $\begin{array}{l}\mathrm{CH}\left<\begin{array}{c}\mathrm{N}\\ \|\\ \mathrm{N}\end{array}\right.\\ |\\ \mathrm{COOC_2H_5}\end{array}$ is obtained by the action of nitrous acid upon the hydrochloride of ethyl aminoacetate, $\begin{array}{l}\mathrm{CH_2NH_2HCl}\\ |\\ \mathrm{COOC_2H_5}\end{array}$.

Dibasic Acids (*Chem.*) Acids which form two salts with a monovalent element, such as sodium, potassium, or silver; or with a monovalent group, such as the ammonium group ($\mathrm{NH_4}$), or the methyl ($\mathrm{CH_3}$) or ethyl ($\mathrm{C_2H_5}$) groups. Thus sulphuric acid, $\mathrm{H_2SO_4}$, is a dibasic acid because it forms the salts $\mathrm{NaHSO_4}$ (sodium hydrogen sulphate) and $\mathrm{Na_2SO_4}$ (sodium sulphate), etc.

Dicarboxylic Acids (*Chem.*) Organic acids containing two $-\mathrm{COOH}$ groups are called dicarboxylic acids. Thus, the simplest possible dicarboxylic acid is oxalic acid, $\begin{array}{l}\mathrm{COOH}\\ |\\ \mathrm{COOH}\end{array}$.

Diced. *See* DIAPER.

Dichlamydeous (*Botany*). The term used in description of a flower when both whorls of the perianth are present.

Dichroism (*Min.*) The property some minerals have of exhibiting two different colours when viewed in two different directions, *e.g.* IOLITE or DICHROITE.

Dichroite (*Min.*) A synonym for IOLITE (*q.v.*)

Dichromate Cell. *See* CELLS, PRIMARY.

Dicotyledones (*Botany*). One of the two divisions of flowering plants, characterised by the presence of two cotyledons or seed leaves in the embryo.

Didactics. The art or science of teaching.

Didymium (*Chem.*) This substance occurs in cerite along with Cerium, Lanthanum, and Samarium: it was formerly regarded as a single element, as solutions of its salts yield a characteristic absorption spectrum. But it has been resolved by fractional crystallisation of the double nitrate with ammonium into two others: NEODYMIUM, giving pink salts; and PRASEODYMIUM, giving green salts, and both having characteristic absorption spectra. Neodymium is itself most probably not a single element.

Die (*Architect.*) The cube-shaped body of a pedestal. It is also known as the dado. *See* PEDESTAL *and* DADO; *also* ARCHITECTURE, ORDERS OF.

—— (*Eng., etc.*) (1) An engraved stamp employed for impressing a design upon some softer material, such as coins, medals, etc. Dies are often used in pairs for impressing different designs on the opposite

sides of the article stamped. (2) A cutting tool used for forming an external screw thread. *See* STOCKS AND DIES.

Die Box (*Eng.*) The part of a SCREWING MACHINE (*q.v.*) which contains the DIES.

Die Chuck (*Eng.*) A chuck in which work is held by two (or three) small jaws, carried in radial slots along which they can be moved to or from the centre of the chuck. Sometimes the jaws are actuated by mechanism, so that they move simultaneously; the chuck then becomes SELF-CENTRING.

Dielectric (*Elect.*) Insulating or non-conducting material through which lines of electric force run from one charged body to another. *See also* SPECIFIC INDUCTIVE CAPACITY.

Diesis (*Phys.*) The interval between two notes whose frequencies are as 25 : 24. It is the difference between a minor tone (frequency ratio $\frac{10}{9}$) and a limma ($\frac{16}{15}$).

Die Square (*Carp.*) Rough timber of a square section, not sawn.

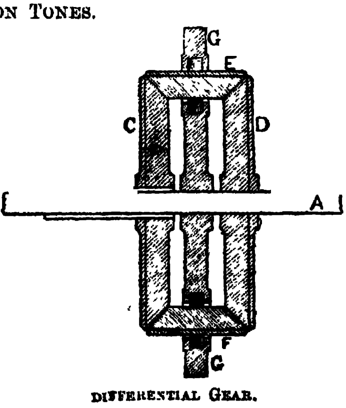
Diethylamine (*Chem.*) $NH(C_2H_5)_2$. A colourless inflammable liquid with strong ammonia-like smell; boils at 56°; soluble in water; a strong base. For preparation, *see under* ETHYLAMINE. It is a secondary amine. Its chief reactions are: (1) With ethyl oxalate it forms ETHYL DIETHYLOXAMATE, $\begin{array}{l}CON(C_2H_5)_2\\ |\\ COOC_2H_5\end{array}$, a liquid. (2) With nitrous acid it forms NITROSODIETHYLAMINE $(C_2H_5)_2N.NO$, a yellow liquid. (3) With ethyl iodide it forms TRIETHYLAMINE HYDRIODIDE, $N(C_2H_5)_3HI$. (4) With acetylchloride it forms DIETHYLACETAMIDE, $(C_2H_5)_2N.OC.CH_3$.

Difference of Phase (*Phys., etc.*) *See* HARMONIC MOTION.

Differences, Marks of, *or* **Brisures** (*Her.*) Distinguishing marks or figures added to heraldic compositions for the purpose of identifying different members of a family who have the right to bear the paternal arms. For instance, eldest sons bear their fathers' arms differenced with a label as a distinguishing mark; the second bears a crescent, the third a mullet, the fourth a martlet, and so forth. These are used during the lifetime of the father.

Difference Tone (*Sound*). When two notes sounding together produce beats (*q.v.*), a tone can sometimes be heard whose frequency is equal to the difference of the frequencies of the two original tones. This deeper tone is termed a Difference Tone. *See also* COMBINATION TONES.

Differential Gear (*Motor Cars*). A train of wheels connecting the two halves of the driving axle of a car with the shaft which transmits the power from the engine. This permits the wheels of the car to revolve at different rates when turning a corner, but causes both to revolve together when driving straight forward. In a typical form A and B are the two halves of the axle; D and C are bevel wheels keyed on A and B; G is the rim of the sprocket wheel, *i.e.* the wheel by means of which the power is transmitted from the engine to A and B; E and F are small bevel wheels, gearing with C and D, and carried on axles fixed to the sprocket wheel G. In straightforward driving E and F do not rotate, and therefore C and D turn with G. When the whole vehicle is caused to turn from its previous straight path, E and F can rotate in such a way as to allow a difference in the rate of rotation of the two half axles A and B.



DIFFERENTIAL GEAR.

Differential Motion (*Cotton Weaving*). A very important and essential motion on the flyer frames for determining the reduction in speed of bobbin spindles as the diameter of bobbin increases during the winding on of the roving which is given off by the draw rollers. There are several motions, the chief of which are as follows: (1) Holdsworth's; (2) Curtis & Rhodes'; (3) Dobson & Barlow's; (4) Tweedale's; (5) Brooks & Shaw's. Sometimes termed "Jack-in-the-box."

—— (*Eng.*) (1) Differential gear (*q.v.*) such as is used in motor cars. (2) Any mechanism in which a motion is obtained which is the difference of two separate motions; *e.g.* in the so-called Chinese windlass, in which one end of a chain is unwound from a barrel, while the other end is wound up on a larger barrel, thus raising the loop or bight of the chain at a slow rate.

Differential Pulley. A block with a set of pulleys and an endless chain. The mechanical advantage depends on the difference between the diameters of the pulleys.

Diffraction. The general name for the phenomena produced when light passes through any very small opening or past some obstacle casting a shadow. According to ordinary experience in such cases sharp shadows are produced, whereas, according to any wave theory, sharp shadows should not be produced. When, however, light diverges from a point source or a very narrow slit, maxima and minima of illumination are produced outside, and sometimes inside, the geometrical shadow, giving rise to what are termed DIFFRACTION BANDS, and these can be shown to be exactly in accordance with theory when the very small length of light waves is taken into account.

Diffraction Grating. An arrangement practically equivalent to a large number of very narrow slits close together, thus vastly increasing the brilliancy of the diffraction effects obtained. They are produced by ruling some surface, such as glass (transmission grating) or metal (reflection grating) with from 5,000 to 40,000 lines or scratches to the inch. The best gratings are ruled on a concave metallic mirror of small curvature, a method introduced by Rowlands. Good gratings are very costly, but useful replicas can be obtained on gelatine films. Diffraction gratings are used for the production of spectra without the aid of a prism, and their main importance lies in the fact that they afford almost the only practical method of accurately measuring the wave length of light.

Diffusiometer (*Phys., Chem.*) A piece of apparatus used in examining the rate of diffusion of gases. It is merely a straight glass tube, one end of which is closed by a porous material such as plaster of Paris or a thin piece of gas carbon, the other end being open. The porous end is covered with a sheet

of rubber; the tube is filled with mercury and inverted over mercury, and the gas to be examined is passed in. The level of mercury inside and outside being the same, the rubber is removed at a given instant, and the process of diffusion begins. The mercury levels being kept as nearly as possible the same during the experiment, the rubber cap is put on again after a known interval, and the amount of air which has entered the tube, as determined by analysis, during the time of the experiment measures the rate of diffusion of the gas relative to that of air.

Diffusion (*Phys.*, *Chem.*) This term in its widest sense implies the spontaneous mixing which occurs when two or more substances are brought in contact with each other. The phenomenon is most pronounced in gases. When two gases are brought together they rapidly mix, even against gravity. Thus, if two flasks be joined together by a glass tube passing through rubber stoppers, and the lower flask be filled with carbon dioxide and the higher with hydrogen, the gases will form a homogeneous mixture after some time, in spite of the fact that the carbon dioxide is twenty-two times as heavy as the hydrogen. Graham showed by means of the DIFFUSIOMETER (*q.v.*) that gases diffuse at a rate which varies inversely as the square roots of their densities; *e.g.* the density of hydrogen being one and that of oxygen sixteen, hydrogen diffuses four times as quickly as oxygen. Liquids also have the power to diffuse into each other; but the process is incomparably slower than in the case of gases, and there is no such simple law of diffusion in the case of liquids as that which holds in the case of gases. Dissolved substances have also the property of diffusing through the liquid serving as solvent; thus a solution of copper sulphate may be placed in a tall cylinder and water cautiously poured upon it so as not to mix with the solution. On standing, the copper sulphate will be seen to pass very slowly up the cylinder into the water. Solids also diffuse into each other, but very slowly. A plate of high carbon steel pressed against a plate of pure iron gives up carbon to the iron even at ordinary temperatures. The phenomena of diffusion are explained on the supposition that the molecules of matter are in a state of rapid motion. In gases the molecules have the greatest freedom, so that mixture takes place readily; while in liquids and solids the molecular conditions are much more complex, and diffusion is much slower. The passage of a gas through a porous material into another gas is also called diffusion, and the law of gaseous diffusion holds the same whether there is a partition or not. A partition is useful when it is desired to effect a partial separation of two gases which differ sufficiently in density.

Diffusivity (*Phys.*) The ratio between the conductivity of a substance and its specific heat per unit volume. If k = the coefficient of conductivity, s the specific heat, and ρ the density of the body, the diffusivity or, as it is also called, the coefficient of thermometric conductivity $= \dfrac{k}{s\rho}$.

Digester (*Paper Manufac.*) A strong steel vessel used for boiling rags, esparto, and other raw materials.

Digesters (*Chem. Eng.*) Apparatus of various forms (generally provided with stirrers or a false bottom) for "cooking" materials with steam, usually under pressure, *e.g.* in the separation of oil, fat, or grease from fish offal, slaughter-house refuse, and bones.

Digestion (*Zoology*). The process by which the food is changed into soluble substances that will readily diffuse through the walls of the alimentary canal into the blood. *See* CHYME, *etc.*

Digger (*Civil Eng.*) A term applied to a mechanical excavator.

Digitalin. The alkaloid obtained from the leaves of the foxglove, *Digitalis purpurea* (order, *Scrophulariaceæ*).

Diglyph (*Architect.*) A projecting face used in the Doric entablature, similar to a triglyph, but having only one complete and two half channels. *See* TRIGLYPH.

Dihydric Alcohols and Phenols (*Chem.*) Alcohols and phenols containing two hydroxy groups. Thus glycol is a dihydric alcohol, $\begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array}$; hydroquinone is a dihydric phenol, $C_6H_4(OH)_2$ (1 : 4). *See also* ALCOHOL.

Dihydro (*Chem.*) A prefix implying the addition of two hydrogen atoms to a compound. Thus dihydrobenzene is a compound formed by the addition of two atoms of hydrogen to benzene: C_6H_6, Benzene. C_6H_8, Dihydrobenzene.

Dihydroxy (*Chem.*) A prefix implying the presence in a compound of two hydroxy groups. Thus tartaric acid is called dihydroxysuccinic acid, because it may be regarded as succinic acid in which two hydrogen atoms are replaced by two hydroxy groups.

$$\begin{array}{lcl} CH_2COOH & \quad & CHOHCOOH \\ | & & | \\ CH_2COOH & & CHOHCOOH \\ \text{Succinic acid.} & & \text{Dihydroxysuccinic acid.} \end{array}$$

Dihydroxytartaric Acid (*Chem.*), $\begin{array}{l} C(OH)_2COOH \\ | \\ C(OH)_2COOH \end{array}$. *Also called* DIOXYTARTARIC ACID. An unstable crystalline solid melting at 114°. To make it tartaric acid is dissolved in fuming nitric acid, mixed with concentrated sulphuric acid, and allowed to stand; the solid, which separates, is carefully brought into ice cold water and allowed to stand some days. The solution of the acid so obtained yields a nearly insoluble sodium salt; it has been suggested as a test for sodium. With phenylhydrazine parasulphonic acid it yields a beautiful golden yellow dye, TARTRAZINE,

$$\begin{array}{l} HOOC\,.\,C : N - NHC_6H_4SO_2OH \\ \qquad\quad | \\ HOOC\,.\,C : N - NHC_6H_4SO_2OH \end{array}$$

Dike. A DYKE (*q.v.*)

Diketones (*Chem.*) Compounds containing two ketone (—CO—) groups. The simplest diketone is diacetyl, $CH_3CO\,.\,COCH_3$. When the ketone groups are adjacent they are called α or 1 : 2 diketones; when separated by a CH_2 group, β or 1 : 3 diketones; and so on. DIACETYL is interesting because it has a yellow colour and a smell like quinone (*q.v.*), which is an aromatic diketone. ACETONYLACETONE is important because of the readiness with which it yields derivatives of the heterocyclic ring compounds, FURFURANE, THIOPHENE, and PYRROL. It is a pleasant smelling liquid, boiling at 194°, and may be prepared from ethyl acetoacetate (*q.v.*) by making the sodium compound, treating this with iodine, and allowing the resulting ethyl diacetyl-

succinate to stand in contact with caustic soda solution.

$$\begin{array}{l} CH_3COCH \,.\, COOC_2H_5 \\ \;\;| \qquad\qquad\qquad\qquad + 2H_2O \\ CH_3COCH \,.\, COOC_2H_5 \end{array}$$

$$\begin{array}{l} CH_3CO \,.\, CH_2 \\ \qquad\quad | \qquad + 2CO_2 + 2C_2H_5 \,.\, OH \\ CH_3CO \,.\, CH_2 \end{array}$$

Acetonylacetone can exist in the tautomeric (*see* TAUTOMERISM) form, $CH_3C \,.\, OH = CH - CH = C \,.\, OH \,.\, CH_3$. Heated with phosphorus pentoxide, it forms *aa*-DIMETHYL FURFURANE:

$$\begin{array}{l} CH_3C = CH \\ \quad OH \\ \quad OH \\ CH_3C = CH \end{array} \qquad \begin{array}{l} CH_3 \,.\, C = CH \\ O\langle \\ CH_3 \,.\, C = CH \end{array} \quad + H_2O.$$

With phosphorus pentasulphide (which withdraws water and gives SH_2) we get *aa*-DIMETHYL THIOPHENE,

$$\begin{array}{l} CH_3 \,.\, C = CH \\ S\langle \quad | \\ CH_3 \,.\, C = CH \end{array}$$

With ammonia it gives *aa*-DIMETHYL PYRROL,

$$\begin{array}{l} CH_3 \,.\, C = CH \\ \quad OH \\ \quad OH \\ CH_3 \,.\, C = CH \end{array} \quad NH = 2H_2O + HN\langle \begin{array}{l} CH_3 \,.\, C = CH \\ \\ CH_3 \,.\, C \quad CH \end{array}$$

Dilatometer (*Phys.*) An instrument for determining the cubical expansion of liquids. In one form a bulb is filled with the given liquid at a known temperature, and the increase in volume is obtained by observing the rise of the liquid in the neck attached to the bulb, the cross section of this neck having been accurately determined beforehand. On making a suitable correction for the expansion of the bulb, the true coefficient of cubical expansion of the liquid can be calculated if we know the original volume and the rise in temperature to which the liquid has been subjected.

Dill (*Botany*). *Peucedanum graveolens* (order, *Umbelliferae*). The dried fruits produce on distillation an oil used in pharmacy.

Dillueing (*Mining*). Cornish term for washing powdered ore.

Diluvium (*Geol.*) A name applied by the older generation of geologists to all the superficial accumulations, and especially to those now regarded as of glacial origin. Formerly these diluvial deposits were supposed to have been formed by the Flood, or by some vast and destructive debacle.

Dimensions (*Eng., etc.*) The measurements of work which are shown on working drawings.

Dimensions of Units. The power which shows how a derived unit is related to a fundamental unit; *e.g.* a unit of volume (derived) varies as the *third* power of the fundamental unit of length on which it depends, and therefore the unit of volume is said to be of dimensions three in length. The unit of velocity varies directly as the unit of length, and inversely as the unit of time; its dimensions, therefore, are 1 in length and -1 in time. *See also* UNITS.

Dimethylamine (*Chem.*) $(CH_3)_2NH$. A gas; when liquefied it boils at 7°. In its properties it closely resembles diethylamine (*q.v.*), and it may be prepared in a similar way. It is also prepared by boiling nitrosodimethylaniline (*q.v.*) with caustic soda.

Dimethylaniline (*Chem.*) $C_6H_5N(CH_3)_2$. A colourless oil boiling at 192°. It is prepared on a large scale by heating a mixture of aniline and aniline hydrochloride with methyl alcohol (free from acetone) at 230° to 270°, and fractionally distilling the product. Its hydrochloride with nitrous acid forms NITROSODIMETHYLANILINE (*see* NITROSO COMPOUNDS); with fuming sulphuric acid, dimethylaniline forms the METASULPHONIC ACID. It is largely used in the preparation of dyes; so also is its metasulphonic acid. *See* METHYL ORANGE, METHYL VIOLET, MALACHITE GREEN.

Dimidiated (*Her.*) Cut in halves, and one half removed and replaced by another half similarly treated; thus two coats are sometimes placed on one shield per pale, the half of each only appearing; *e.g.* the arms of the borough of Great Yarmouth are compounded thus.

Diminished Flier (*Join.*) A step slightly narrowed or diminished at one end.

Diminished Interval (*Music*). An interval containing one semitone less than perfect or minor.

Diminished Styles (*Join.*) The STYLES (*q.v.*) of half-glass doors or framing in which the upper part of the style is narrower than the lower part.

Diminishing Socket (*Eng., etc.*) A socket for connecting two pipes of different diameters.

Diminuendo (*Music*). Diminishing the loudness. Abbreviation, DIM. or $>$.

Diminutive (*Her.*) Similar to the "ordinary," only of smaller dimensions and having a different name; thus the "Cotise" is the diminutive of the "Bend," "Barrulet" the diminutive of the "Bar," etc.

Dimity. *See* DIAPER.

Dimmer (*Elect. Eng.*) A device for diminishing the light from electric lamps on the stage of a theatre. It consists of a variable resistance or of an IMPEDANCE or CHOKING COIL (*q.v.*)

Dimorphism (*Min., Chem.*) When a definite chemical compound crystallises in two different forms it is said to show dimorphism; *e.g.* carbonate of lime occurs in the rhombohedral form as calcite, in the rhombic form as aragonite; carbon, in the cubic form as diamond, in the hexagonal form as graphite, etc.

Dinas Clay (*Met.*) A very highly refractory fireclay used for lining metallurgical furnaces. Contains about 30 per cent. more silica and 18 per cent. less alumina than other fireclays.

Dines' Hygrometer (*Meteorol.*) *See* HYGROMETERS.

Dinitrobenzenes (*Chem.*), $C_6H_4(NO_2)_2$. There are three of these, *viz.*

NO_2	NO_2	NO_2
NO_2	NO_2	NO_2
Ortho- (or 1 : 2). M.P. 118°.	Meta- (or 1 : 3). M.P. 90°.	Para- (or 1 : 4). M.P. 173°.

Only the METADINITROBENZENE is important. It is prepared by dissolving benzene in fuming nitric acid, cooling, adding sulphuric acid, and boiling. Pour into water and crystallise from alcohol. It forms yellowish white prisms, melting at 90°. Sparingly

soluble in water, readily in alcohol. On reduction with ammonium sulphide it forms metanitraniline; reduction with tin and hydrochloric acid gives METAPHENYLENEDIAMINE (*q.v.*)

Diœcious (*Botany*). The term used when the flowers are unisexual, and the male and female flowers occur on different plants (*e.g.* willow).

Diopside (*Min.*) A greenish variety of monosymmetric pyroxene with a well marked cleavage. It usually occurs in thermo-metamorphosed marbles. *See* PYROXENE.

Dioptase (*Min.*) A hydrous silicate of copper, $CuSiO_3 . H_2O$. It crystallises in rhombohedra of an emerald green colour. It does not occur in sufficient quantity to be used as an ore of copper. From Siberia, Nassau, Chili, etc.

Diopter (*Surveying*). One of the earliest instruments for the solution of surveying problems. Invented by Hero of Alexandria (B.C. 285—224). Essentially a primitive combined theodolite and level.

Dioptric (*Light*). The unit of curvation in lenses: if r = radius of a curve in metres, then the curvature in dioptries $= \frac{1}{r}$.

Diorama. A mode of scenic representation invented by Daguerre and Bouton (1822). The pictures, which are viewed through an aperture, are translucent in parts, and the method is suitable for illustrating not only landscapes, but also interiors of buildings, clever effects being obtained by means of transmitted and reflected light, aided by screens.

Diorite (*Geol.*) An eruptive rock of deep-seated origin and of the same structure as granite, but consisting essentially of one of the plagioclase felspars, usually in association with one or more ferro-magnesian silicates, amongst which hornblende is usually present. Biotite and a small proportion of quartz usually occur as accessories. Diorite is the deep-seated or plutonic equivalent of andesite lavas and of porphyrite dykes. It grades in one direction into DIORITE GRANITE and in another into DIORITE [GA]BBRO.

Dioscoreaceæ (*Botany*). A natural order of *Dicotyledons*. The plants are natives chiefly of tropical countries, and possess large underground tubers. The tubers of the YAM (*Dioscorea*) form a valuable food.

Diota (*Archæol.*) A vessel with two ears or handles. The term is sometimes used for an AMPHORA (*q.v.*), but it applies practically to any two-handled vase.

Dip (*Elect.*) The inclination of the actual direction of the earth's magnetic force to a horizontal plane.

—— (*Eng., etc.*) (1) The amount of immersion of some object, such as the float of a paddle wheel. (2) The act of dipping work into a liquid bath, *e.g.* in galvanising iron.

—— (*Geol.*) Sedimentary rocks are deposited normally in layers which are as a whole parallel to the horizon. But subsequent disturbances may cause these to bend into folds. The amount of inclination thus caused is usually measured in degrees, counting from the horizontal. In estimating the dip of a rock it is necessary to record the direction of greatest inclination as well as its amount at the place under observation.

Dip Crank (*Eng.*) A crank formed by bending a rod to the required shape, instead of cutting the crank from a solid forging.

Diphenyl (*Chem.*), $C_6H_5 - C_6H_5$. White shining leaflets; melts at 71°; soluble in alcohol. Obtained by heating brombenzene with sodium; or better, by passing vapour of benzene through a redhot iron tube and fractionally distilling the product. Oxidised with chromic acid, it gives benzoic acid. Its chemical behaviour is very similar to that of benzene. It occurs in coal tar.

Diphenylamine (*Chem.*), $HN{<}{}^{C_6H_5}_{C_6H_5}$. Monoclinic plates; melts at 54°; soluble in alcohol, benzene, ether. Obtained by heating aniline and aniline hydrochloride for a long time at 200°, boiling the product with dilute hydrochloric acid to remove aniline, and distilling the residue. It is a weak base, its salts being decomposed by water. It unites with potassium, forming $(C_6H_5)_2NK$. Heated with chloroform in presence of aluminium or zinc chlorides, it yields ACRIDINE. It is used in the preparation of dyes; *e.g.* DIPHENYLAMINE BLUE is made by heating diphenylamine with oxalic acid, which gives CO_2.

$$3NH(C_6H_5)_2 + CO_2 = C \begin{cases} C_6H_4NHC_6H_5 \\ C_6H_4NHC_6H_5 \\ C_6H_4NC_6H_5 \end{cases} + 2H_2O.$$

See also TROPÆOLINES. A solution of diphenylamine in concentrated sulphuric acid is a very sensitive reagent for nitrites, nitrates, or chlorates, with all of which it gives a deep blue colour.

Diploïdion *or* **Diploïs** (*Archæol.*) A chiton or tunic worn by Greek women. The portion of the garment above the waist was double, and the outer fold hung loose. The term is sometimes applied to this outer fold itself.

Dip of the Horizon (*Astron., etc.*) If an observer be placed some distance above the surface of the earth, the most distant point which he can see is the extremity of a line drawn from his eye at a tangent to the earth. The angle which this line makes with a horizontal plane through the eye is called the DIP OF THE HORIZON.

Dippel's Oil. BONE OIL (*q.v.*)

Dipping (*Pot.*) The process of immersing the bisque ware in the liquid glaze, which is melted upon the ware subsequently in the glost oven.

—— (*Chem. Eng.*) Immersion in an acid bath prior to electroplating or galvanising.

Dip Pipe (*Gas Manufac.*) *See* GAS MANUFACTURE.

Dipropargyl (*Chem.*), $CH \vdots C . CH_2 . CH_2 . C \vdots CH$. A mobile liquid with penetrating odour, and boiling at 85°. It is isomeric with benzene, C_6H_6, but differs from it by the ease with which it polymerises, combines with bromine, and undergoes oxidation.

Dipteral (*Architect.*) A temple which has two rows of columns on each of its long sides. *See also* PSEUDO-DIPTERAL.

Dipterocarpaceæ (*Botany*). A dicotyledon order belonging to India. The trees all contain resin, and yield many economic products. *See* CAMPHOR.

Diptych (*Archæol.*) (1) A tablet consisting of two leaves connected by hinges, generally made of metal, wood, or ivory. The inner surfaces were covered with wax, and upon these the ancients wrote with a stylus. (2) The ornate tablets distributed by the consuls to commemorate their tenure of office, and

bearing their names and portraits. (3) A public register or list of the names of consuls and other magistrates.

Diptych (*Ecclesiastical*). (1) A register of martyrs, bishops, and other orthodox persons, living or dead, mentioned in the prayers of the Church. (2) The intercessions in the course of which the names were mentioned.

—— (*Art*). A painting or other work of art, generally an altarpiece, in the form above described. *See* TRIPTYCH.

Direct (*Music*). A mark (*w*) placed at the end of a stave on a line or space to indicate the note in the following corresponding stave.

Direct Cotton Dyes. *See* DYES AND DYEING.

Direct Process (*Met.*) The production of wrought iron (or steel) from the ore without the usual intermediate stage in which cast iron is produced.

Direct Spokes (*Cycles*). Those which are radial to the axis of the wheel. *Cf.* TANGENT SPOKES.

Direct Vision Spectroscope (*Phys.*) *See* SPECTROSCOPE.

Dirk (*Armour*). (1) A dagger or poniard formerly used by Highlanders and still worn as part of a Highland costume. (2) The small sword formerly worn by junior naval officers.

Dirty Proof (*Typog.*) Proof sheet having many corrections, owing to mistakes in composition.

Di-saccharides (*Chem.*) *See* CARBOHYDRATES.

Disc *or* **Disk.** (1) A flat thin circular plate of any material. (2) In body armour a plate of metal for protecting the body at certain joints of the armour: a ROUNDEL. (3) The surface of the sun, moon, or a planet as it appears projected in the heavens. *See* DISCUS.

Disc Armature (*Elect. Eng.*) *See* ARMATURES.

Disc Crank (*Eng.*) A crank formed by a disc of metal keyed on the crank shaft. The crank pin is fixed near its periphery. It is simpler to make and more easy to balance than an ordinary crank. In many petrol motors the pair of flywheels forms the disc crank. *See* PETROL ENGINES.

Discharge (*Eng.*) (1) Liquid flowing from a pump, etc. (2) The rate of flow of the same liquid; that is, the amount passing in a given unit of time (minute or second, etc.)

——, **Electric.** In general, the loss of charge by electrified bodies, or the flow of electricity along any path, but tacitly limited to those cases in which a dielectric forms part of the circuit, and the discharge therefore becomes more or less disruptive, giving visible phenomena, such as a brushlike glow, succession of sparks, vacuum tube effects, etc.

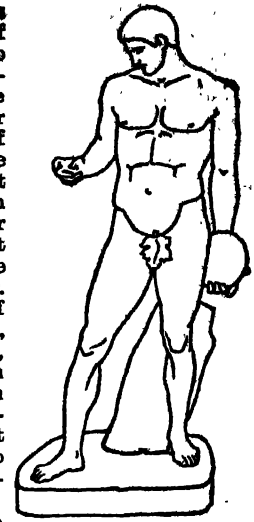
Discharge Valve (*Eng.*) A valve through which the DISCHARGE (*q.v.*) leaves a pump: used in steamships to permit the CIRCULATING WATER to escape.

Discharging Arch (*Build.*) An arch built over a LINTEL (*q.v.*) to relieve it of the weight above.

Discobolus (*Class. Antiq.*) A thrower of the DISCUS or quoit. The term is applied also to a statue representing a man in the act of throwing the discus. It was a favourite subject with ancient sculptors, and there are several admirable statues extant.

Discolouring (*Dec.*) A defect in enamelled work (*q.v.*), in which white enamel becomes somewhat yellow, due to either an improper selection of white pigment or driers used in the manufacture of the enamel. The defect cannot be remedied.

Disconnecting Traps (*Hygiene*). The purpose of a disconnecting trap is to prevent free communication between the air of the public sewer and the air of the house system of drainage. It should be fixed at a point as distant as may be practicable from the building, and as near as practicable to the point at which the drain may be connected with the sewer. The trap should be self cleansing, not too large, free from all mechanism, and provided with an efficient "seal." To obtain access for inspection purposes it is desirable that the disconnecting trap should be fixed in a manhole.



DISCOBOLUS OF NAUCYDES, NAPLES.

Disconnector (*Build.*) *See* DISCONNECTING TRAP.

Discord (*Music*). A chord requiring resolution and often preparation. Discordant intervals are all intervals, except those given as CONCORDANT (*q.v.*) *Also called* DISSONANCES.

Disc Piles (*Civil Eng.*) Piles (*q.v.*) in the form of a hollow tube of cast iron, furnished with a broad flange forming a foot at the lower end; used in sandy ground. The sinking is accomplished by scouring out the sand under the foot by means of a jet of water under pressure, which is forced through a pipe running down the inside of the pile.

Discs of Armature Cores (*Elect. Eng.*) Thin sheet iron of the best quality (*e.g.* Swedish charcoal iron), from ·04 to ·08 in. thick, is stamped into discs of suitable form for building up the armature cores of dynamos and motors.

Discus (*Archæol.*) A disc, generally of metal, used in ancient Greek and Roman athletic games. *See* DISCOBOLUS.

Disc Valve (*Eng.*) Usually a disc of rubber, fastened down by a bolt through the centre on a flat seat containing perforations. Liquid can rise through these openings, the disc of rubber lifting and thus providing a passage.

Disc Wheel (*Eng.*) A wheel without any radial arms: it may have a thickened boss and rim, or be of uniform thickness.

Disengaging Gear (*Eng.*) Levers, etc., for operating CLUTCHES (*q.v.*)

Dished (*Carp.*) A hole in a board is said to be dished when the edge is bevelled.

Dishing (*Eng., etc.*) A formation often given to wheels and discs in which the centre lies out of the plane of the rim; greater stiffness is gained by using this form.

Disinfectants (*Hygiene*). Substances capable of destroying the specific organisms which cause disease. Their mode of action may be either physical or chemical. Belonging to the former class is heat, which is the best disinfectant, especially moist heat. Among the chemical disinfectants are perchloride of mercury (corrosive sublimate), formalin, carbolic

acid (phenol), sulphur dioxide. Disinfectants, to be effectual, must be of sufficient strength and thoroughly applied to the articles or rooms undergoing disinfection. *See* SANITATION.

Disintegrators (*Chem. Eng., etc.*) Machines for grinding dry substances. Most modern types do not grind, but disintegrate by concussion; *i.e.* two concentric discs with projecting steel arms or "beaters" are rotated in opposite directions in a beating chamber or casing, into the top or side of which the material to be pulverised is fed. There are many variants of this type, differing mainly in the disposition and driving of the beaters.

Dispersion (*Light*). The splitting up of a beam of white light (or other composite light) into its component colours by some method depending upon the variation in the refractive indices of the latter. *See* SPECTRUM.

——, **Anomalous.** Some substances used as prisms produce a dispersion in which the order of wave lengths is not the same as that produced by a glass prism; *e.g.* a solution of fuchsine deviates red light more than violet. These anomalous effects are always dependent upon the existence of absorption. Thus light waves falling upon a glass prism probably set the molecules in vibration, but as their natural period does not coincide with that of any of the visible waves of light, the result is a forced vibration of small amplitude, and very little light is absorbed. But if the natural period of some constituent of the prism is the same as that of some wave length in the incident light, then the result is "resonance," and that particular wave length is absorbed; *i.e.* the refractive index for it becomes infinite, and an absorption band is produced in the spectrum. It is only natural to expect that abnormal effects should occur for those wave lengths which are just too great or just too small to give resonance, and as a matter of fact experiment and theory show that the refractive index is abnormally increased for those wave lengths which are just too great, and abnormally diminished for those wave lengths which are just too small. Hence the order of colours is changed. These effects are somewhat difficult to observe, as they are generally produced by strongly coloured substances, which necessitate the use of prisms of very small refracting angle.

Displacement (*Mech.*) The amount a body has been moved from any given position.

—— (*Eng.*) The space swept through by a piston in each stroke: it equals the area of piston multiplied by the length of stroke.

Displacement Cylinder (*Eng.*) An auxiliary cylinder (used in certain forms of gas engine) in which the charge (*q.v.*) is compressed previous to entering the working cylinder. *See also* GAS ENGINES.

Displacer Piston (*Eng.*) A piston occasionally used in gas engines for driving out the burnt gases from the working cylinder.

Displayed (*Her.*) The wings of birds of prey are "displayed" when they appear spread or expanded; for other birds' wings so expanded the term is "disclosed."

Display Work (*Typog.*) Type displayed or not set solid, as in JOBBING WORK (*q.v.*), titles, heads, etc. The object is to attract attention.

Disposition (*Paint., etc.*) The judicious arrangement of figures, etc., in a picture, or of the several parts in a building.

Dissipation of Energy (*Phys.*) The process by which the total amount of available energy is continually being diminished. For example, when fuel is burnt to work an engine, the rejected heat, or heat which is not converted into work, is allowed to escape; and though it may contribute to the raising of the temperature of the air, or of neighbouring objects, it cannot be recovered and utilised. It has not been destroyed, but it has ceased to be available.

Dissociation (*Phys., Chem.*) When certain substances are placed under suitable conditions of temperature or pressure or solution, the molecules composing them are resolved into simpler molecules, atoms, or ions; and when the original conditions are restored the original substances are reproduced. This phenomenon is called dissociation. If ammonium chloride (not absolutely dry) be heated, its vapour is found to weigh half as heavy as we should expect it to do if it consisted of molecules of the formula NH_4Cl, but exactly what we should expect if it consisted of equal numbers of molecules of ammonia and hydrochloric acid gas, formed by the decomposition of the ammonium chloride according to the equation $NH_4Cl = NH_3 + HCl$. When the vapour is cooled the ammonium chloride is reproduced. In the state of vapour, therefore, ammonium chloride is dissociated. Examples of substances which undergo a like change are: Iodine at 1500°, $I_2 = I + I$; phosphorus at 1750°, $P_4 = P_2 + P_2$; hydriodic acid, $2HI = H_2 + I_2$, above 150°; nitrogen peroxide, $N_2O_4 = NO_2 + NO_2$; and many others. At a given temperature each gaseous product of dissociation exerts a definite pressure called the DISSOCIATION PRESSURE; if at this temperature the pressure of a constituent be increased and kept above the dissociation pressure, the original substance will be reproduced and no dissociation will be possible. Salts of weak acids and bases undergo dissociation in a precisely similar manner on solution in water. Any acid, base, or salt whose solution in water is a conductor of electricity undergoes ELECTROLYTIC DISSOCIATION when dissolved in water. For example, common salt (NaCl), when dissolved in water, is resolved to an extent depending on the strength of the solution into the ions (*see* IONS) $\overset{+}{Na}$ and $\overset{-}{Cl}$. The undissociated part and the ions obey the law of mass action (*see* MASS ACTION), so that if the quantity of salt be put = 1, and the dissociated part = a, and the volume of the solution containing one gram molecule v, we have $k = \dfrac{\frac{a^2}{v^2}}{\frac{1-a}{v}}$.

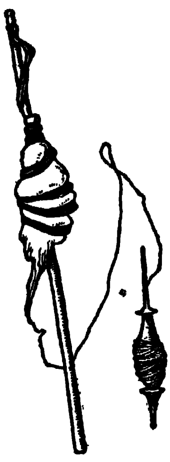
Where k is a constant depending on the nature of the dissolved substance, it is called the DISSOCIATION CONSTANT for the particular substance.

Dissociation Coefficient (*Elect.*) *See* IONISATION COEFFICIENT.

Dissolving Lantern *or* **Dissolving Views.** The exhibition of slides in such a manner that one view fades away and another gradually becomes visible. This is effected by the use of two (or more) lanterns focussed simultaneously on the screen. The light from one is gradually obscured, either by interposing an opaque screen or by turning off the supply of oxygen gas; this causes the image of the slide to fade away, and meanwhile the reverse process is gone through with the second lantern, and the image produced by it grows in intensity till the full amount of brilliancy is attained.

Dissonance (*Sound*). The effect produced by two notes whose frequencies are such as to produce BEATS (*q.v.*) Also termed a DISCORD (*q.v.*) in music.

Distaff (*Archæol.*) A staff about 3 ft. long, round one end of which flax or wool for spinning was wound. The ancients used a cane, split at one end and formed into a receptacle for the material to be spun. In spinning, the distaff was held under the left arm, the wool or flax being drawn from it through the fingers of the left hand, and twisted spirally by the thumb and forefinger of the right hand. The operation was aided by a spindle attached to the end of the thread, and which hung down. When the spindle touched the floor the length of thread was wound round it, and the operation repeated. In Art the distaff is sometimes employed as a symbol of the female sex and female authority. *See* COTTON, LINEN, SILK, WOOLLEN MANUFACTURE.



DISTAFF AND SPINDLE.

Distance (*Paint.*) The effect obtained by contrasting the darker tones and richer colours in the foreground of a picture with the lighter tones and more delicate colours beyond; and by maintaining the correct diminution of scale—in accordance with the laws of perspective—in the objects represented as they recede from the eye. In a landscape the distance and middle distance are the parts of the composition which are not occupied by foreground or sky; they are assumed to be comparatively remote from the observer.

Distance of Visible Horizon or Offing (*Astron.*) *See* OFFING.

Distemper (*Dec.*) A water paint used principally for plaster and stucco work, and made by mixing whiting (*q.v.*) with water and some adhesive substance such as size, and with or without the addition of colour. Distempering is the cheapest process of painting; it is free from gloss, and capable of giving very artistic effects. Scenic artists use distemper almost exclusively, while all wallpapers excepting those known as SANITARIES (*q.v.*) are printed in distemper colours. On ordinary walls and ceilings distemper is applied over a coat of claircolle (*q.v.*) Only one coat is given, and this must be applied quite evenly, so as to avoid patches. Some colours cannot be used in distemper, as the lime in the plaster destroys them. The following is a list of the colours which may safely be employed, and from them can be obtained any shade, tint, or hue, including black and white:—*Whites:* Barytes, blanc fixe, whiting, satin white, zinc oxide, lithopone, Orr's white, gypsum, terra alba, china clay. *Colours:* Yellow ochre, sienna, umber, Vandyke brown, cadmium yellow, vermilion, red lead, red oxide, red ochre, Venetian red, Indian red, light red, ultramarine, cobalt blue, chrome green, cobalt green, emerald green, malachite green, and all black pigments. During the past few years washable distempers have increased in use very considerably. They are made in a large variety of permanent colours, and in some cases may be applied to wood and varnished over.

Distemper or **Tempera** (*Paint.*) (1) A method of painting in which opaque colours are used mixed with water and with some glutinous substance soluble in water—*e.g.* size, yolk or white of egg, etc. The painting is executed upon a ground of chalk or dry plaster (*gesso*), which is generally spread upon wood, but sometimes upon canvas. This method is to be distinguished from *fresco*, in which the colours are applied to a fresh and moist surface of plaster. (2) The term is applied likewise to the pigments used in this process. *See* PAINTING, METHODS OF.

Distillation (*Phys.*, *Chem.*) The process of heating a substance in a vessel until it boils, conducting its vapour into a cooling arrangement called a condenser, and collecting the condensed vapour in a receiver. The object of such a process is: (1) To separate a liquid from any dissolved solid it may contain; *e.g.* when tap water is distilled the solids, such as calcium carbonate, which it contains are left in the still, and very nearly pure water is obtained in the receiver. (2) To separate a more volatile liquid from a less volatile. (3) To separate a volatile product obtained in a chemical reaction from other less volatile products; *e.g.* when potassium nitrate is distilled with sulphuric acid, nitric acid is produced, and, being more volatile than any other substance present, it distils over alone at a moderate temperature. As the boiling point of a liquid depends on the atmospheric pressure, and some liquids undergo decomposition at their boiling points, it is necessary to distil such liquids under reduced pressure. This is done by connecting the receiver to some form of air pump, so as to reduce the pressure in the apparatus to the desired degree; *e.g.* lævulinic acid boils with decomposition at 239° under ordinary pressure, but under 12 mm. it distils unchanged at 144°. In some cases it is possible to separate a mixture of two liquids of different boiling points by a process of FRACTIONAL DISTILLATION. In this process the distillate is collected in fractions as the boiling point of the mixture rises. Suppose we have a mixture of equal parts of benzene (B.P. 81°) and toluene (B.P. 110°); collect fractions every 5° from 80 up to 110°; now redistil fraction 1 (80 to 85°), most of it passes over below 85°. At 85° add fraction 2 (85 to 90°), and again distil; some will pass over below 85°, and is collected in 80 to 85° receiver. Now change receiver and collect 85 to 90° fraction, and so on. After three or four operations it will be found that the lowest and highest fractions are much the greatest, and consist of benzene and toluene respectively. Numerous organic liquids placed in water and submitted to the action of a current of steam from boiling water will distil over with the steam, even though the liquid have a much higher boiling point than water. This is called DISTILLATION IN STEAM. A very important instance of this is found in the preparation of aniline (*q.v.*), where the aniline has to be separated from a solution of sodium stannate and sodium chloride by distillation in a current of steam. DESTRUCTIVE DISTILLATION is simply heating a substance out of air so as to decompose it and collect the products of decomposition. The preparation of coal gas and coal tar is an example of destructive distillation.

Distillation in Steam (*Chem.*) *See* DISTILLATION.

Distortion (*Astron.*) The change of shape of the sun and moon when near the horizon owing to differential refraction of the upper and lower limbs.

—— (*Photo.*) The production of an image of incorrect form, due to the SPHERICAL ABERRATION (*q.v.*) of the lens, tilting of the camera, etc.

Distress (*Eng.*) Excessive strain in a structure, caused by undue loading.

Distribute (*Typog.*) To replace type (after printing) in the case, each letter, etc., being returned to its proper compartment, ready for resetting.

Distributed Load (*Eng., etc.*) A load which is spread out over the whole of a beam or other member of a structure. A wall carried by a girder is an example: the weight of the wall is spread out over the whole of the girder.

Distyle (*Architect.*) Having two columns. The simplest form of Greek temple is known as DISTYLE-IN-ANTIS. In this form of temple there are two columns between the antæ. *See* ANTA, TETRASTYLE, DECASTYLE, HEXASTYLE, *and* OCTASTYLE.

Ditriglyph (*Architect.*) An arrangement of the Doric frieze and intercolumniation so that two triglyphs are obtained between those immediately above two adjacent columns. This necessitates a wider intercolumniation than the usual arrangement, in which there is only one triglyph over the space between two columns. *See* TRIGLYPH; ARCHITECTURE, ORDERS OF; ENTABLATURE; MONOTRIGLYPH; *and* TRITRIGLYPH.

Diurnal Range (*Meteorol.*) Applied to the changes which occur during the day (twenty-four hours) in temperature, atmospheric pressure, etc.

Divalent Elements (*Chem.*) *See* VALENCY.

Divided Bearing (*Eng.*) A BEARING (*q.v.*) in which the BUSH, or part which provides the actual bearing surface, is divided into two (or occasionally more) parts. These parts can be adjusted to take up wear, as in the common PLUMMER BLOCK (*q.v.*)

Divided Pitch (*Eng.*) The distance from one thread to the next in a multiple-threaded screw If there are n threads of pitch l, the divided pitch
l

Dividers. Compasses used solely for measuring off distances. They are often provided with a screw adjustment.

Dividing Engine (*Phys., Eng., etc.*) A machine for ruling scales. The subdivision of the fundamental measurements usually depends on an accurately cut screw furnished with a graduated head.

Divi-divi (*Botany*). A valuable tanning material consisting of the pods of *Cæsalpinia coriaria* (order, *Leguminosæ*), which are very rich in tannin. *See also* DYES AND DYEING.

Divinity Calf (*Binding*). Dark brown calf, finished in blind tooling or antique. So called from its use being almost limited to theological books.

Divisi, Divided (*Music*). An orchestral term implying that the instruments playing the part so marked are to divide into firsts and seconds.

Division Peg *or* **Point** (*Eng.*) The peg which holds a DIVISION PLATE (*q.v.*) at rest in any required position.

Division Plate (*Eng.*) In lathes for ornamental and special work a plate is fixed on the mandrel and divided into a convenient number of parts by rows of holes arranged in concentric circles. The mandrel can then be turned through a definite fraction of a revolution and fixed by means of a pin, termed the DIVISION PEG, thus enabling drilling, etc., to be carried out on the work at definite points round its circumference. The work remains fixed, and is acted on by the drill, milling cutter, etc., which may be driven from an OVERHEAD MOTION (*q.v.*) The number of holes in the various rows varies. A good set should include 96, 100, and 360, with some number of which seven is a factor. Others may be added if the plate be large enough.

Do (*Music*). The sol-fa syllable for C.

Dobbie *or* **Dobby** (*Cotton Weaving*). A machine which takes the place of a tappet, and produces more elaborate weaves. Its capacity for pattern production is also much greater. There are numerous types, some of which are positive and others negative in their action. The following are the chief: Ward's, Keighley, Blackburn, Burnley, Dobcross, Catlow.

—— (*Silk Manufac.*) A small machine placed at the top of power loom, for raising and depressing the HEDDLES (*q.v.*) according to the tie arranged upon it. Used only for plain fabrics such as twills, satins, checks, etc.

Dock Gates (*Civil Eng.*) Watertight doors of wood and metal, generally made in two parts which are hinged at the outer edge, and provided with sluices. They are usually operated by hydraulic power. To enable the gates to withstand the pressure of the water, they are so hung that they meet each other at an angle when closed, the apex of the angle being directed inwards, *i.e.* towards the side on which the water is highest. The greater the pressure of water the greater the force with which the gates are kept closed. They can only be opened when the level of the water is the same (or very nearly so) on both sides of the gates.

Docks (*Civil Eng.*) Enclosed spaces for the accommodation of ships; they communicate with the water in the outside channel by means of DOCK GATES (*q.v.*) Instead of opening directly to the channel, these gates may open into a tidal basin (*q.v.*) If a dock can be emptied of water to permit of repairs to the ship's hull, it is termed a DRY DOCK.

Dock Walls (*Civil Eng.*) Massive walls of concrete or masonry; a space between the wall and the ground behind is usually excavated, and filled in with hard material, well rammed in. If the ground below is treacherous, the foundations of the walls may rest on PILES.

Doctor. The technical name for a copper soldering iron or bit.

—— (*Chem. Eng.*) The scraper attached to the last roller of a plodding machine (*q.v.*), which removes the soap in strips or ribbons.

—— (*Paper Manufac.*) A flat iron bar used for keeping PRESS ROLLS and DRYING CYLINDERS free from small fragments of paper.

Dodder (*Botany*). *Cuscuta*. A genus of the order *Convolvulaceæ*, which have become parasitic on many plants. They are leafless and rootless, and do much damage to their hosts.

Doeskin (*Woollen Manufac.*) Fine woollen cloth with fibrous face, the weave being five or eight end sateen or doeskin. It is the reverse of the buckskin (*q.v.*) both as regards twill effect and finish.

Doffer (*Textile Manufac.*) A wire-covered cylinder or drum (about 24 in. diameter) on carder at the opposite end to licker-in, which collects the carded fibres from the large cylinder in the form of a thin sheet or WEB, prior to being contracted into a SLIVER

(*q.v.*) Also applied to the attendant who "doffs" the full bobbins on fly and spinning frames, and replaces with empties.

Doffing (*Textile Manufac.*) The process of removing the material in carding, and also in removing the yarn from the spindle in spinning.

Dogfish (*Zoology*). The flesh of the dogfish (*Scyllium canicula*; family, *Scyllidæ*) is used as food in a fresh or dried state. The skin forms a kind of shagreen, used in wood polishing.

Dog Legged Stairs (*Join.*) Stairs which have the outside strings vertically above each other.

Dogs (*Carp., etc.*) Iron cramps used for drawing up glued joints.

—— (*Eng.*) (1) The jaws of a chuck or similar device for holding work. (2) A lathe CARRIER (*q.v.*)

Dog's Ear (*Plumb.*) The corners of a lead tray turned into a fold.

Dog's Tooth (*Build.*) Bricks laid with one corner projecting, in a brick cornice.

Dog-tooth (*Architect.*) The characteristic ornament of the Early English style, generally used in a hollow moulding. *See* TOOTH ORNAMENT.

Dog Wheel (*Eng.*) A RATCHET WHEEL (*q.v.*)

Doh (*Music*). The first degree or note of the scale in the MOVABLE DOH or TONIC SOLFA system.

Dolabra, *dimin.* **Dolabella** (*Archæol.*) A cutting instrument: chisel, celt, axe, varying in shape according to the purpose for which it was used. Ornate dolabræ were used by the pontifices for slaughtering the sacrifices. Caxton refers to the dolabre (adze) as the trademark of carpenters.

Dolce (*Music*). Sweetly.

Doldrums (*Met.*) The equatorial region of calms between the surface winds of the two hemispheres. The position of this region varies a little, but it is a little to the north of the terrestrial equator.

Dolente, Con Dolore (*Music*). Sorrowfully.

Dolerite (*Geol.*) An intrusive rock of basic composition, in which a glassy or lithoidal ground mass is either absent or occurs only in small quantity. The structure is ophitic; *i.e.* the felspars, which have been formed at an early stage, are enveloped within the (later formed) pyroxene. The essential constituent minerals are: (1) LABRADORITE, usually in lath shaped crystals; (2) a PYROXENE enclosing them; (3) some ILMENITE; and (4) commonly some OLIVINE. The rock never occurs as a lava, but usually either as a sill or a dyke.

Dolium (*Archæol.*) A large earthenware jar, spherical in shape, used by the Romans for holding wine, oil, corn, etc. Vessels of this character are in use in India at the present day.

Dolly (*Cycle Manufac., etc.*) A soft mop, rotated at a high speed on a polishing head, for putting the final polish on work to be plated.

—— (*Eng.*) The tool used for holding up the head of a rivet while closing or riveting up.

—— (*Mining*). A heavy tool (often of wood) used for crushing minerals.

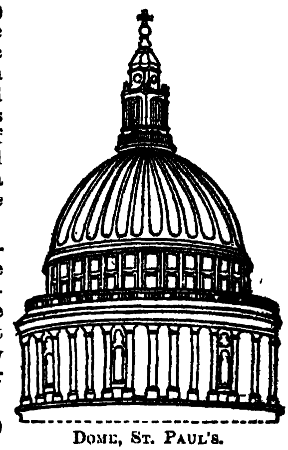
Dolmen (*Archæol.*) A French name for a prehistoric structure consisting of two parallel rows of upright stones with large flat stones placed horizontally across them, forming a passage: a CROMLECH. *See* PREHISTORIC ARCHITECTURE.

Dolomite (*Min.*) Calcium magnesium carbonate, $CaMg(CO_3)_2$. It occurs in rhombohedral crystals, the faces of which are usually curved; colour white, yellow, pink, brown, to almost black. Also massive (MAGNESIAN LIMESTONE). Does not effervesce with 20 per cent. hydrochloric acid in the cold, but does when warmed in it. Iron may replace the other bases to almost any extent; the darker and more curved specimens usually contain the greater amount of iron. A limestone that has been dolomitised is of less bulk than the original, and often shows peculiar structures due to molecular rearrangement. Magnesian limestone is a good building stone, as it is so slowly affected by weathering. Some of the massive varieties are used in making hydraulic cement. Its distribution is very wide.

Dolphin (*Art., etc.*) (1) A conventional figure of a species of cetaceous mammal, having a large head. They are especially used as decorations on fountains. (2) In heraldry they are represented with the bodies bent in a semicircle. (3) A French gold coin at one time current in Scotland.

—— (*Zoology*). The dolphins and porpoises belong to the family *Delphinidæ* of the mammalian order *Cetacea*. Many species—for example, the bottle-nosed dolphin of America—yield a valuable oil.

Dome (*Architect.*) The cupola was one of the characteristic features of the Italian *duomo* (cathedral), and the term dome was taken from the name of the building, and used to denote the cupola type of roof. *See* CUPOLA.



DOME, ST. PAUL'S.

—— (*Eng.*) A dome-shaped chamber on the head of a boiler, supposed to increase the steam space and collect dry steam. Is gradually being discarded in favour of a DRY PIPE (*q.v.*)

Domeykite (*Min.*) Arsenide of copper, Cu_3As_2. Copper = 71·63, arsenic = 28·57 per cent. It occurs in tin white octahedra. More often in reniform masses. It occurs at Coquimbo and at Copiapo in Chili.

Dominant (*Music*). The technical name of the fifth note of a scale. Its frequency is one and a half times that of the KEYNOTE (*q.v.*)

Dominant Tone (*Paint.*) A term used to describe the principal or predominating colour or tone in a picture.

Dongola Leather. Goatskins tanned by a combination of vegetable and mineral tanning agents, as alum and salt followed by gambier or other vegetable tan, or chrome salts followed by vegetable tan; or, *vice versa*, vegetable tan followed by alum or chrome. Dongola leather is now made from calf, sheep, and split hide, as well as goat.

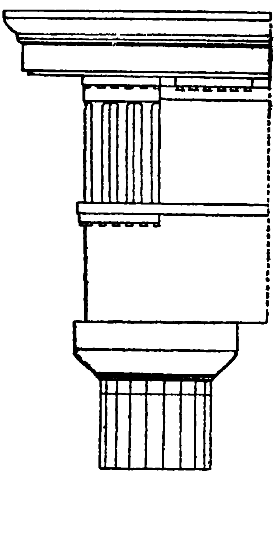
Donjon (*Archæol.*) The principal tower or innermost keep of a castle, usually built on a natural or artificial mound. It served as the last retreat of the garrison in case of necessity, its lower part being used as a prison. Known also as the KEEP, DONJON KEEP, TOWER.

Donkey Engine (*Eng.*) A small auxiliary engine used to drive the feed pumps, circulating pumps, and other subsidiary machinery on a steamship.

Doppler's Principle (*Phys.*) When there is any relative motion between a source of sound and a listener, the number of waves received per second is different from that corresponding to the actual frequency of the source, and hence the apparent pitch is altered, being increased for motions of approach and diminished for motions of recession. If V = velocity of sound, v_s = velocity of source, v_1 = velocity of listener, n — actual frequency of source, then the apparent frequency is $n \times \left(\frac{V \pm v_s}{V \mp v_1}\right)$, the upper signs signifying approach. The principle has only theoretical interest in the case of sound, but it is true for wave motion generally, and its application to light has been of the highest importance, as it enables the velocity of stars and other heavenly bodies in the line of sight to be measured by the displacement of their spectral lines.

Dorian (*Music*). *See* MODES.

Doric Order (*Architect.*) The earliest and most severe of the orders used by the Greeks. *See* ARCHITECTURE, ORDERS OF.


DORIC-GREEK, TEMPLE OF THESEUS, ATHENS.

Dormer Window (*Architect.*) A vertical window formed in and projecting above the surface of a sloping roof. The rooms which receive light from windows of this form are usually sleeping apartments; hence the name.

Dornick (*Textiles*). *See* DIAPER.

Dorsed (*Her.*) *See* AVERSANT.

Dorse, Dorsel, Dossal, Dossel, Dosser (*Furniture*). (1) Ornamental cloth, frequently tapestry, hung at the back of a seat, or used to cover the back of a chair, especially a throne or chair of State, or forming a canopy or curtain at the back of such a seat. (2) An ornamental cloth, usually embroidered, hung at the back of the altar or at the sides of the chancel. (3) Hangings placed round a hall or on the walls of a room of State. (4) In some churches the backs of stalls are ornamented with carvings in imitation of such hangings. *See* LINEN FOLD.

Dot (*Music*). (1) Placed after a note or rest, it adds one half the value to the note or rest. Each succeeding dot is one half the value of the preceding dot. (2) Placed over or under a note, it makes that note half note half rest. *See* STACCATO. Two dots placed at a double bar (:‖ or ‖:) show that the section on the side of the dots is to be repeated.

Dot (*Plastering.*) A small dab of plaster to serve as a guide for the rule in forming a SCREED (*q.v.*)

Doublé (*Binding*). A style introduced from France, in which coloured morocco leather is used on the insides of the cover instead of board papers. The insides are elaborately finished, frequently with a dentelle (*q.v.*) border, while the outside is comparatively plain, with only a few lines in blind tooling.

Double Acting Engine (*Eng.*) An engine in which the steam (or gas) acts on each side of the piston alternately. All modern steam engines were of this type till the introduction of very high speed steam engines for coupling direct to dynamos led to the revival of SINGLE ACTING ENGINES (*q.v.*)

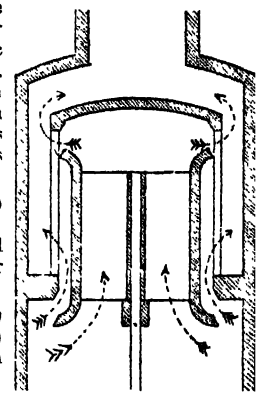
Double Acting Pump (*Eng.*) A pump in which the piston is forcing water on one side while drawing water into its cylinder or barrel at the other; in the return stroke the process is reversed. Such a pump requires valves working in a manner similar to that of a steam engine; they must, however, remain open right to the end of the stroke.

Double Acting Steam Hammer (*Eng.*) A STEAM HAMMER (*q.v.*) in which steam can be used above the piston to intensify the blow.

Double Bar (*Music*). Two perpendicular lines across the stave showing the end of a movement or section.

Double Bass. *See* MUSICAL INSTRUMENTS: STRING (BY BOW).

Double Beat Valve (*Eng.*) A valve of circular plan, with two concentric seating faces. *See* FIGURE. The pressure on this form of valve is much less than in the common lift valves or slide valves, and it is easier to move.


DOUBLE BEAT VALVE.

Double Belting (*Eng.*) Two thicknesses of leather sewn or otherwise fastened together to give greater strength.

Double Broad (*Typog.*) Furniture double the width of broad, *i.e.* eight picas in width.

Double Butted Spokes (*Cycles*). Spokes with the ends thicker than the central portion, for the purpose of making the joint with rims and hubs stronger.

Double Butt Joint (*Eng.*) A butt joint with covering strips on each side; the rivets go through three thicknesses of metal.

Double Cases (*Typog.*) Cases specially made for small jobbing founts, the upper and lower cases being made in one.

Double Cone Moulding (*Architect.*) A Norman enriched moulding, consisting of a series of truncated cones placed end to end.

Double Contraction (*Pattern Making*). When IRON PATTERNS (*q.v.*) are used, the original wooden pattern from which the iron pattern was cast must have all allowances for contraction doubled, as the iron pattern itself must have the ordinary contraction allowance (*i.e.* must be larger than the final casting) in order to give the proper dimensions to the latter.

Double Crown. The size of a printing paper which measures 30 by 20 in.

Double Cut File (*Eng.*) The ordinary form of file, which has two sets of teeth, one crossing the other.

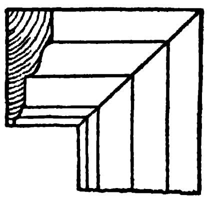
Double Cylinder Engine (*Eng.*) An engine having two cylinders acting on the same crank shaft.

Double Demy. The size of a printing paper which measures 35 by 22½ in.

Double Driver Chuck (*Eng.*) A DRIVER (*q.v.*) with two pins, which act on each end of the carrier at once.

Double Ended Boiler (*Eng.*) A boiler with a fire-box at each end : used in marine practice.

Double Ended Bolt (*Eng.*) A bolt with no head, but with a thread at each end on which a nut is screwed.



DOUBLE FACED ARCHITRAVE.

Double Faced Architrave (*Join.*) A moulding round a door or window opening with two plane faces, one sunk below the other.

Double Faced Hammer (*Eng.*) *See* HAMMERS.

Double Faced Skirting (*Join.*) A form of skirting (*q.v.*) built in two parts, the lower part projecting in front of the upper part.

Double Fagoted Iron (*Eng.*) Iron which has been put through the operation of fagoting (*q.v.*) twice over.

Double Flat (*Music*), (♭♭). A sign which lowers a note a whole tone.

Double Flemish (*Build.*) Flemish bond showing on both sides of the wall. *See* FLEMISH BOND.

Double Floor (*Carp.*) A double floor consists of BINDERS, CEILING JOISTS, BRIDGING JOISTS, and FLOOR BOARDS (*q.v.*) *See also* FLOORS.

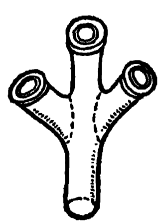
Double Flued Boiler (*Eng.*) A LANCASHIRE BOILER. *See* BOILERS.

Double Foolscap. A size of paper. In printing paper, 27 by 17 in.; and in writing paper, 26½ by 16⅝ in.

Double Frame (*Typog.*) A composing frame usually made of deal and holding two pairs of cases at the same time. *See* CASE.

Double Gearing (*Eng.*) A train of wheels containing two pinions and two wheels. The BACKGEAR (*q.v.*) of a lathe is an example.

Double Headed Rail (*Civil Eng.*) The form of rail now used in most permanent ways; it can be reversed when worn, as the top and bottom are of the same cross section.



DOUBLE JUNCTION.

Double Hung (*Join.*) Sashes that are hung with cords and weights.

Double Imperial. The size of a printing paper measuring 44 by 30 in.

Double Junction (*Build.*) A pipe with a branch on each side of it.

Double Lath (*Build.*) A strip of wood ⅜ in. thick.

Double Letters (*Typog.*) Old face letters such as ct, ft, and diphthongs Æ, Œ, æ, œ, etc.

Double Margin Door (*Join.*) Where it is inconvenient to have folding doors, and the opening is too wide for a well proportioned door, a door is constructed with four styles, with a bead down the centre to make it look like a pair of folding doors.

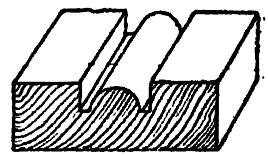
Double Narrow (*Typog.*) Furniture double the width of a narrow, *i.e.* six picas in width.

Double Pica (*Typog.*) A fount two small picas in depth, and in size between paragon and two line pica. *See* TYPE.

Double Ported D Slide Valve (*Eng.*) A special form of SLIDE VALVE (*q.v.*) intended to facilitate the escape of the exhaust steam by means of ports in the valve itself, which has a hollow cast in it of the form of a capital D.

Double Post. A size of printing paper usually 32 by 20 in.

Double Pott. A size of printing paper which measures 25 by 15 in.



DOUBLE QUIRKED BEAD.

Double Quirked Bead (*Join.*) A bead with two quirks (*q.v.*).

Double Refraction (*Phys.*) A doubly refracting body is one in which the velocity of light is different in different directions, instead of being independent of direction, as in glass or water. Singly refracting substances like glass may, however, be made doubly refracting by setting up internal stresses, by pressure, or by unequal expansion. This variability of light-velocity with direction implies the existence of definite molecular structure. It occurs in all crystals except those belonging to the cubic system. Every such substance has one direction (UNIAXAL CRYSTALS), and many two directions (BIAXAL CRYSTALS), along which they behave to light as singly refracting substances, possessing a definite refractive index (called the ORDINARY INDEX). This direction is called an OPTIC AXIS, and the two extremes of light-velocity occur for vibrations executed at right angles to the optic axis and along the optic axis respectively. The former velocity is the greater in "positive," and the latter in "negative" substances. When light passes through the substance in any direction other than along an optic axis, it may be regarded as consisting of two portions, one executing its vibrations perpendicular to the axis and having a constant velocity and index (the ORDINARY RAY), and another whose vibrations are at right angles to the former, and whose velocity, and therefore index, depends upon the inclination of the ray to the optic axis. This is the EXTRAORDINARY RAY, and its refractive index varies between the value for the ordinary ray and another value which is either greater or smaller than the former, accordingly as substance is "positive" or "negative." If the substance be sufficiently thick, these portions emerge as two distinct rays which have undergone unequal refraction.

Double Riveting (*Eng.*) Two lines of rivets instead of one. The latter is more commonly used.

Doubles (*Eng., etc.*) Sheets of iron from about $\frac{1}{30}$ to $\frac{1}{50}$ in. thick, or 20 to 25 B.W.G. (*see* WIRE

GAUGES), prepared for coating with tin to make TIN PLATE (*q.v.*)

Double Samara (*Botany*). A type of fruit where the pericarp is winged and the fruit breaks into two or more winged portions (*e.g.* maple).

Double Sharp (*Music*). A sign (×) which raises a note a whole tone.

Double Shear Steel (*Met.*) *See* SHEAR STEEL.

Double Shrinkage (*Eng.*) *See* DOUBLE CONTRACTION.

Double Stars (*Astron.*) Stars which lie apparently so near to each other that only a magnifying power will separate them. There are two classes, physical doubles and optical doubles.

Doublet (*Cost.*) A close-fitting garment reaching from the neck to a little below the waist. It was worn in England, generally by men, from about the middle of the fourteenth century until the time of Charles II. It varied extensively in form, sometimes being without sleeves, and sometimes devoid of the short skirt.

—— (*Elect.*) Used in theory of electrical images to denote a system of two small equal charges of opposite sign separated by an exceedingly small distance. The "moment" of the doublet is the product of one of the charges multiplied into distance between them, and this product is always a finite quantity. The term is used in a similar sense in theory of magnetism.

—— (*Photo.*) A photographic lens consisting of two separate single lenses mounted in a tube. By the use of a suitable doublet distortion of the image can be corrected.

Double Tenons (*Carp. and Join.*) Two tenons side by side and parallel to each other. If doubled in width only, they are termed single tenons. *See* TENONS.

Double Threaded Screw (*Eng.*) A screw with two parallel threads (*i.e.* two separate helices) instead of one; used in certain cases where a comparatively fine thread of quick pitch is required.

Double Warp (*Lace Manufac.*) When the warp system of threads numbers twice that of the bobbin system. Two warp threads to one bobbin thread throughout the whole width of the web.

Double Webbed Girder (*Eng.*) A BOX GIRDER, *i.e.* one with the top and bottom booms united by two parallel webs.

Doubling (*Cotton Manufac.*) The twisting together of two or more threads so as to make one strong resultant thread known as FOLDED YARNS. Used for making strong fabrics, sewing cotton, crochet cotton, etc. Three forms of machines are used: (1) the ring doubler, (2) the twiner, (3) throstle or flyer. Cotton threads may be either (*a*) dry doubled, (*b*) wet doubled. The term is sometimes used when running two or more threads together on a bobbin without twisting.

Doubling Course (*Build.*) A double row of slates at the eaves of a roof. *See* ROOFS.

Douglas Fir. *See* WOODS.

Doulting Stone. *See* BUILDING STONES.

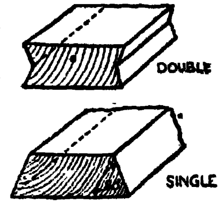
Doup, Doupe, or Dupes (*Textile Manufac.*) A type of heald used in gauze weaving. *See* HEDDLE.

Doup, Doupe, or Dupes (*Silk Manufac.*) An interlacing coupling or lash used in the manufacture of gauze, also for making a fast edge when two or more widths of work are made together in a loom.

Dove (*Art*). (1) In Christian art the dove is the symbol of the Holy Ghost. (2) A vessel in the form of a dove was formerly used for enclosing the Pyx in Eastern churches.

Dovetailing (*Join.*) Dovetails consist of splayed pins on one part and sockets on the other. The splay or slope should be 80°, *i.e.* 10° out of square. In common dovetailing the joints are visible in both boards. In dovetailing used in drawer fronts the joint can be seen on the side of the drawer, *i.e.* in one board only. In BLIND or SECRET DOVETAILING, used in some kinds of finished cabinet work, the joints are entirely concealed, so that the two boards appear to be MITRED (*q.v.*) together.

Dovetail Key (*Join.*) A form of wooden key with its edges sloping.



DOVETAIL KEYS.

Dovetail Saw. A light tenon saw used for cutting dovetails, and for small work generally.

Dowel (*Carp., Build., etc.*) (1) A wooden pin used in joining two boards edge to edge instead of a tongue and groove. (2) An iron pin fixed in a stone in such manner that a portion of it projects and fits into a hole made in another stone alongside. The joint thus made is called a DOWEL JOINT. (3) A short piece of slate, used in making a joint in masonry.

—— (*Pattern Making*). In pattern making the dowelled joints are intended to come apart easily for convenience in moulding. The dowels are usually brass or iron pins, fitting into metal sockets; they are provided with flanges, by which they are screwed to the pattern.

Dowel Plate. A steel plate with holes in it for making wooden dowels of various sizes: the wood is trimmed roughly to size and then driven forcibly through a hole in the plate. As the hole is made slightly conical, a cutting action is exerted which trims the wooden rod up to a cylindrical form.

Dowlas (*Linen Manufac.*) (1) A heavy plain texture linen used in the brown state for aprons and in white for interlinings of collars, shirt fronts, etc. (2) The name applies also to a strong calico made in imitation of the foregoing.

Downpipe (*Plumb.*) A rainwater pipe.

Downtake (*Met., etc.*) (1) A passage by which hot gases are led from the cone of a blast furnace to the base. (2) Any passage for the downward flow of gases, etc., as in some forms of boiler setting.

Downthrow (*Geol.*) The amount of dislocation which rocks have undergone where they have been let down by faults. The correlative to downthrow is UPCAST.

Dowson Gas (*Eng.*) A mixture of WATER GAS and PRODUCER GAS (*q.v.*), formed by blowing air and steam through redhot coke. Its uses are much the same as producer gas, but it has a greater calorific value.

Dutch Marble Paper (*Binding*). A marbling (for either paper or book edges) in which the colours are drawn together and intermingled by means of a wire comb. Thus in place of the ordinary "shells" or "veins," Dutch marble presents a series of small sharp scollops of varying colours.

Dracæna (*Botany*). A genus of *Liliaceæ* remarkable for their arborescent growth. The resinous exudation from the stem is one source of DRAGON'S BLOOD, and the leaf fibres are used in commerce.

Drachm *or* **Dram.** *See* WEIGHTS AND MEASURES.

Draff. Spent grain from a whisky mash.

Draft (*Eng., etc.*) A preliminary sketch. Less frequently the term is used for a drawing otherwise than preliminary.

—— (*Textile Manufac.*) *See* DRAFTING.

Drafted Margins (*Masonry*). A narrow margin chiselled round the edges of stone blocks, the centre portion of the stones being hammer dressed.

Drafting (*Textile Manufac.*) Arranging the order in which the threads are to be drawn through the healds. Usually imparted to the drawer-in by means of a chart or plan called a DRAFT or DRAFTING PLAN. *See* DRAWING IN.

—— (*Lace Manufac.*) The art of arranging and manipulating on paper the various threads that will eventually compose the pattern of lace in the lace machine. The correct attainment of all the necessary movements of the threads by mechanical means.

Drag (*Foundry*). The lower portion of a MOULDING BOX (*q.v.*)

—— (*Typog.*) A term applied to a printed sheet which shows slurring or doubling.

Drag Bar (*Eng.*) The bar by which a truck, locomotive, traction engine, etc., is attached to a following truck.

Drag Bolt (*Eng.*) The bolt sometimes used in fastening DRAG BARS (*q.v.*) together.

Drag Link (*Eng.*) The levers, etc., used to move the LINK MOTION (*q.v.*) of an engine.

Drag on Armature Conductors (*Elect. Eng.*) The mechanical force experienced by a conductor in which a current is flowing when moved so as to cut across magnetic lines of force. This drag is at right angles to the conductor and tangential to the armature, and tends to rip the windings off the surface of the core. If the conductors are wholly or partially embedded in iron, this drag is transferred, wholly or partially, from the conductors to the iron. This fact is of vital importance in electrical engineering.

Dragon Beam (*Join.*) A beam keyed to the angle tie at the corner of a building to receive the thrust of a HIP RAFTER (*q.v.*) *See also* ROOFS.

Dragon's Blood (*Paint., etc.*) A rich dark red pigment made from a brittle resin which encrusts the scaly fruit of an East Indian palm, *Calamus draco*, which yields also the RATTAN CANE of commerce. Formerly obtained from the stem of several species of *Dracæna* (*Liliaceæ*). Dragon's blood is soluble in alcohol, benzene, carbon disulphide, and caustic soda. On destructive distillation it yields, among other products, toluene and styrene (*q.v.*) It is much used as a pigment in various varnishes, French polish, etc.

Drag Plate (*Eng.*) The hinder part of the base plate of a locomotive, so called because the DRAG BAR (*q.v.*) is fastened to it.

Drag Spring (*Eng.*) A powerful spring attached to a DRAG BAR (*q.v.*) to diminish the sudden jerk when the engine starts.

Drag Surface (*Eng.*) The surface of the blade of a screw propeller which is next to the vessel.

Drainage (*Sanitation*). Strict attention to the drainage system of houses is highly important from the hygienic standpoint. In a modern system of drainage the following requirements, amongst others, should be complied with: (*a*) all drains to be watertight; (*b*) carefully laid on a bed of concrete with a suitable fall; (*c*) all inlets to the drains, except ventilating openings, to be properly trapped; (*d*) drains to be disconnected from the sewer by means of a trap, at which point a manhole should be built; (*e*) branch or tributary drains should join one another obliquely in the direction of the flow, and not by right-angled junctions; (*f*) all joints to be well made; (*g*) adequate provision made for ventilation. *See also under* SANITATION.

Drain Cock (*Eng.*) A small tap for running off water condensed in the cylinder of an engine. Also termed a PET COCK.

Drains and Water Closets (*Hygiene*). *See* SANITATION.

Dram *or* **Drachm.** *See* WEIGHTS AND MEASURES.

Drapery Panel (*Join.*) A panel carved to represent the folds of drapery. *See* LINEN FOLD.

Draught (*Eng.*) The air supply of a furnace or boiler fire. *See also* NATURAL DRAUGHT, FORCED DRAUGHT.

—— (*Pattern Making*). The tapering off of a pattern to facilitate its removal from the mould.

—— (*Textiles*). *See* DRAFTING.

Draught Bar (*Eng.*) A DRAG BAR (*q.v.*)

Draw (*Cotton Spinning*). Referring to the complete outward and inward run of a mule carriage, usually a stretch of 63 to 64 in. During the complete draw all the operations necessary in the spinning and winding of a thread are performed. The speed of the mule is usually indicated by the number of draws per minute.

—— (*Typog.*) A term applied to part of a line of type drawing out on to the roller during the inking of the forme, owing to imperfect justification.

Drawback (*Foundry*). A portion of a mould which can be removed from the rest to enable the pattern to be withdrawn, etc. A drawback is supported by an iron frame or plate of suitable shape, and is rigidly fixed in place when the casting is being made.

Draw Bar (*Eng.*) A DRAG BAR (*q.v.*)

Draw Bit (*Lace Manufac.*) The movable portion at the end of the dropper slides or boxes to which the guide bars are attached, enabling them to be correctly adjusted.

Draw Boring (*Carp. and Join.*) A method of fixing (and drawing up the shoulders of) tenons with wooden pins. The pin is driven into a hole bored through the tenon and the material on each side of the mortice.

Draw Boy (*Textile Manufac.*) A piece of mechanism for operating the frame containing the cords for lifting the harness and forming a shed in the warp. Formerly performed by a boy.

Draw Door Weirs (*Civil Eng.*) A WEIR or DAM (*q.v.*) in which the water is retained by doors or gates which can be raised vertically when there is too large an amount of water passing, as in floods. The HALF TIDE LOCK at Richmond furnishes an example.

Draw Filing (*Eng.*) Putting a finish on metal by moving a file backwards and forwards in a direction at right angles to its own length, so that the teeth only act very slightly.

Drawing (*Cotton Spinning*). A drawing out or attenuation of slivers prepared on the carder or comber with the object of reducing inequalities in thickness, and also further attempting to place individual fibres parallel by means of four lines of rollers revolving at different speeds.

—— **Architectural.** Drawing to scale with mathematical instruments, plans, elevations, perspective views of buildings, or portions of buildings.

Drawing Box (*Textile Manufac.*) One of a series of machines for straightening and attenuating the wool in making worsted yarn.

Drawing Down (*Eng.*) Altering or diminishing the cross section of a forging by hammering.

Drawing Fires (*Eng.*) The removal of a fire when the steam is no longer needed.

Drawing, Freehand. The practice of drawing in outline, from diagrams, forms either natural or conventional, without mechanical aid; the hand being under guidance of the eye only. It constitutes part of the elementary training of a draughtsman.

Drawing from Nature. Depicting by means of pen, pencil, or brush any natural object, animate or inanimate. The drawing may be either a complete work of art in itself, or may be simply a study, to be used as material for pictorial work or design.

Drawing from the Cast. Drawing from a *facsimile* of natural objects or objects of art which have been reproduced in plaster of Paris. The uniform whiteness of the cast (*q.v.*) renders it specially suitable for the study of light and shade.

Drawing from the Flat. Copying in "freehand" flat diagrams of objects, ornaments, or pictures.

Drawing In (*Textile Manufac.*) The ends or threads are drawn singly or otherwise through the eyes or mails of healds or harness in some prescribed order, so as to produce a definite pattern or design in the cloth. Also termed LOOMING.

Drawing, Machine. Plans, elevations, sections, etc., of machinery and engineering structures accurately drawn to scale. They are prepared in the "drawing office" for the guidance of pattern makers, boiler and engine smiths, fitters, turners, machinists, and the men employed in the erecting shop. They give full details and measurements of every part of the piece of work, and the construction and erection are carried out according to these details.

Drawing of Patterns (*Foundry*). The removal of patterns from the mould.

Drawing of Tubes (*Eng.*) *See* TUBES.

Drawing On *or* **Pulling On** (*Eng.*) The method by which large wheels are set on their shafts. Large bolts are fixed to a heavy metal cross (which is rigidly attached to the shaft), so that their nuts pass between the arms of the wheel, and press on the latter by means of plates. The tightening up of the nuts gradually forces the wheel on to the shaft.

Drawing Pen. A pen in which the ink is retained between two flat blades of steel bent towards each other at their points. The distance apart of the blades can be regulated, and the pen then produces lines of great uniformity.

Drawing Process (*Textile Manufac.*) *See* DRAWING.

Drawing Temper (*Eng.*) The partial removal of the hardness or temper (*q.v.*) of steel by heating it to redness and cooling slowly. It is really a form of annealing (*q.v.*)

Draw Knife. A knife with a handle at each end set at right angles to the blade. Used for trimming up wood, especially long pieces, of small width or diameter.

Draw Loom (*Textile Manufac.*) A type of harness loom used before the invention of the Jacquard, so called on account of the harness being drawn or lifted by a draw boy in forming the shed.

Draw Plate (*Eng.*) The perforated plate, usually of hardened steel, through which wire is "drawn." *See* WIRE DRAWING.

Draw Rollers (*Cotton Spinning, etc.*) Essential adjuncts to spinning machinery. Fitted on to draw frames, flyer frames, ring frames, mule, and comber. In England they are usually covered with specially prepared sheepskin leather. Three chief forms: (1) Solid leather covered. (2) Loose boss. (3) Metallic fluted roller.

Dredger (*Civil Eng.*) A machine for excavating the bottom of a channel, *i.e.* one which works under water, as opposed to an EXCAVATOR (*q.v.*), which works on dry land.

Drenching (*Leather Manufac.*) Light skins for moroccos or gloves after bating are "drenched" in a tepid solution of bran and water. The gluten of the bran ferments, forming organic acids. These acids open up and swell the skins, and dissolve out any remaining lime.

Dresden. The royal Saxon porcelain manufactory commonly known as "Dresden" was established at Meissen on the Elbe, about ten miles from Dresden, in the year 1710, Herr Böttger being director. It was fostered under the direct patronage of August II., Elector of Saxony. The manufacture was, and still is, exclusively confined to hard paste, and the productions have become celebrated throughout Europe for beauty, refinement, and a characteristic style. "Dresden china" is perhaps best known by the dainty models of "Watteau" figures which were so largely used for the ornamentation of clocks, tazzas, candelabra, etc. In addition to these, the productions of the manufactory include a great variety of models of birds and animals, and useful and ornamental china of practically every description. *See* BÖTTCHER.

Dresser (*Eng.*) A block fitting into an anvil, over which certain bent work is forged.

—— (*Plumb.*) A wooden tool, usually boxwood, for flattening out sheet lead.

Dressing (*Cotton Manufac.*) A process of warp preparation for the loom. There are several systems, two of which are given. YORKSHIRE DRESSING (for coloured work): In this system the yarn is ordered in the ball warp, and after being dyed and sized, all the threads are run side by side, according to pattern, on to the weaver's beam. SCOTCH DRESSING (for grey work): The yarns are run from back beams placed at both ends of machine, through a paste or size, on to the weaver's beam fixed in the centre. A more particular and expensive process than sizing, and adopted for best work only.

—— (*Lace Manufac.*) A process applied to machine made lace which can only be carried out while the lace is in the "web" or piece. It implies and comprises all the various processes of scouring, bleaching, mordanting, dyeing, staining, and dressing, this last process consisting of stretching the web of lace upon special machinery in a room supplied with heated air and every appliance for drying it quickly after being starched.

—— (*Linen Manufac.*) When linen yarn is being woven, especially if it has passed through any finishing process, it is liable to fray and break. To avoid this it has to be run through a mixture of flour or starch mixed with tallow, wax, gloy, etc., which is called dressing. It is mostly used cold, and differs from the sizing used in the cotton trade.

—— (*Mining*). The separation of the lighter and heavier portions of the crushed ore. *See* TRUE VANNER, *etc.*

—— (*Plumb.*) To dress lead is to flatten it with a DRESSER (*q.v.*)

Dressing a Forme (*Typog.*) Placing the furniture around the naked forme. Sometimes called "clothing a forme."

Dressing Off, Fettling, *or* **Trimming** (*Foundry*). Cleaning up castings, breaking off runners, and removing cores previous to sending the work from the foundry.

Dressings (*Build.*) The stonework fixed round window and door openings.

Driers (*Chem.*) An absorbent powder, generally gypsum or barytes, added to superphosphates to prevent pastiness.

—— (*Dec., etc.*) Materials added to paint to assist in "drying," *e.g.* hardening by the absorption of oxygen. Decorators use principally "patent driers," which are supplied in paste form, and consist of various mixtures, such as zinc sulphate, litharge, and lead acetate ground in boiled oil and mixed with Paris white, white lead, and manganese acetate. Most patent driers are largely adulterated with barytes, gypsum, etc. Liquid driers are used to a limited extent in England, but almost exclusively in the United States. One of the best known varieties is called "TEREBINE," and is made from gum copal, linseed oil, and litharge boiled together. To the use of an excess of driers may be attributed many of the defects which so often occur in house painting. Driers such as red lead, litharge, manganese oxide, borate, sulphate, and oxalate and zinc oxide, and sulphate, sugar of lead, etc., are largely used in the manufacture of boiled oils, varnishes, lacquers, printing inks, coach colours, etc. Driers are sometimes called SICCATIVES.

Drift (*Eng.*) A tool used to give a final form to drilled or punched holes, into which it is driven by a hammer; also used by boilermakers to form a clear hole for a rivet when the punched holes in the plates to be riveted do not exactly coincide.

Drift (*Mining*). A passage or level from one part of a mine to another for working, ventilation, or draining; especially a passage driven in the direction of a mineral vein.

Drift Currents (*Meteorol.*) Ocean currents produced by prevailing winds.

Drifting (*Eng.*) The using of a DRIFT (*q.v.*)

Drill (*Eng., etc.*) A tool for boring holes, held and rotated by some form of brace, drill stock, or machine. The term is often loosely applied to signify the drill stock or drilling machine itself. *See also* TWIST DRILL, *etc.*

—— (*Linen Manufac.*) A twilled texture, usually three, four, or five end; or may be a fancy twill. It is a strong make of cloth used for linings, vestings, trouserings, etc., and is commonly known as three leaf or DIAGONAL DRILL, four leaf or FARMERS' DRILL, and five leaf or MEDIUM or HEAVY DRILL. It is made brown, white, striped, checked, etc.

—— (*Mining*). The tool used for making holes in which explosives are placed for blasting. It is often "armed" with diamond fragments (*see* BORT) for cutting hard rock.

Drill Chuck (*Eng.*) A small CHUCK (*q.v.*) which holds a drill either in a lathe or drilling machine.

Drilled Plates (*Eng.*) The plates of boilers, built-up girders, etc., are often strained considerably by punching the rivet holes. Plates in which all the holes have been made by a drilling machine are free from this fault, and are often used.

Drill Feed (*Eng.*) The mechanism which moves the drill up to its work. It may be automatic or may be worked by the operator.

Drilling Cramp (*Eng.*) A frame or cramp which is used to press a drilling brace or ratchet brace up against a piece of work which cannot be placed on a drilling machine.

Drilling Machine (*Eng.*) A machine worked by hand or power, which drives a drill and at the same time feeds it up to its work. *See also* PILLAR DRILL, RADIAL DRILL, WALL DRILL, *etc.*

Drilling Table (*Eng.*) A cast iron plate, furnished with slots and holes, for holding work in position in a drilling machine.

Drill Plate (*Eng.*) A plate fixed to the loose headstock of a lathe in order to press a piece of work up against a drill fixed in a drill chuck.

Drill Spindle (*Eng.*) The main revolving part of a drilling machine; it carries the drill itself, and can be "fed" or caused to move in the direction of its own length, without ceasing to rotate, by means of the feeding mechanism.

Drip (*Chem. Eng.*) The ACID DRIP is a gauge on a vitriol chamber. It resembles a horn, the wide mouth of which looks upwards in the chamber, while the pointed end is connected to a swan-neck outside. It acts in the same way as a rain gauge, by catching the shower of acid as it forms in the chamber, and collecting it so that the yield and quality can be tested.

—— (*Plumb.*) A step (drip) formed in gutters and flats at the ends of the sheets of lead or zinc to do away with the necessity of soldering.

Dripstone (*Architect.*) *See* FLOOD MOULD.

Driver (*Silk Manufac.*) *See* PICKER.

Driving (*Mining*). A general term for cutting or making a level, adit, or other passage in a mine. The making of shafts is usually termed SINKING.

Driving Axle (*Eng.*) A shaft or axle which transmits rotation to a wheel which is keyed or otherwise fixed on to it.

Driving Blade (*Lace Manufac.*) That part of the Jacquard that contributes the power to move the guide bars.

Driving Chain (*Eng.*) A chain such as that of a cycle or motor car, which communicates motion from one toothed wheel to another. *See* CYCLES.

Driving Chuck (*Eng.*) A chuck with a projecting pin which engages a CARRIER (*q.v.*) fixed on a piece of work running in the lathe between the centres, and causes it to rotate.

Driving Fit (*Eng.*) A piece of work which fits very tightly into its place, so that it can only be driven home (*i.e.* into place) by considerable force applied with a hammer or mallet.

Driving Gear (*Eng.*) (1) The levers and handles by which an engine or machine is controlled. (2) The gearing through which the power is transmitted from one part of a machine to another, *e.g.* from the engine of a car to the driving axle.

Driving Horns (*Elect. Eng.*) Projections which overcome the drag (*q.v.*) on the armature conductors, and cause them to rotate with the shaft and core of the armature. In toothed core discs the teeth themselves serve this purpose.

Driving Side (*Eng.*) The tight side of a belt, *i.e.* the side which is in tension, and therefore transmits the power.

Driving Wheels (*Eng., etc.*) The wheels of a locomotive, car, etc., which are actuated by the engine, and which cause the motion of the vehicle.

Dromos (*Architect.*) An enclosed passage such as one leading to a tomb buried under a tumulus.

Drop (*Carp. and Join.*) *See* PENDANT.

—— (*Met.*) The completion of the decarburisation in the Bessemer process; it is marked by the sudden "dropping" of the flame from the converter.

Drop Black (*Paint., Dec., etc.*) A term applied to a variety of black pigments which are made in an irregular conical form. This is produced by mixing a little gum water with the black and allowing it to drop from the mill in which it is ground. An example is FRANKFORT BLACK, made from vine twigs, cork cuttings, etc.; but other blacks made from bones and animal refuse are often made in this form.

Drop Bottom Cupola (*Met., Foundry, etc.*) A CUPOLA (*q.v.*) in which the bottom can be removed, allowing the remains of the fire, slag, etc., to fall into a pit or space beneath.

Drop Box (*Textile Manufac.*) A type of power loom in which the shuttle boxes have a vertical up and down movement. Originally the boxes dropped simply by gravity.

Dropped Head (*Typog.*) Chapters or sections of a book which commence a new page are usually started about two-thirds the way down the page, and this constitutes a dropped head.

Dropper (*Lace Manufac.*) An instrument of precision used in the Jacquard for the purpose of giving accurate movement to the guide bars. Droppers are selected singly or in combination, and depend upon the principle of the wedge for their effectiveness.

—— (*Mining*). A subsidiary vein running downward from a lode.

Dropper Boxes (*Lace Manufac.*) The space between the slides in the Jacquard, wherein the droppers work. *See* DROPPER.

Dropper Gauge (*Lace Manufac.*) A measure to test the accuracy of droppers of every size or denomination used in any particular lace machine. *See* DROPPER.

Dross (*Met.*) Impurities which rise to the surface of metals when melted; also inferior material generally.

Drosser (*Glass Manufac.*). An iron frame while it is being annealed.

Drug. The Sale of Food and Drugs Act, 1875, defines the term "drug" as including "medicine for internal or external use." Difficulties frequently arise in administration when substances are used both medicinally and commercially. To settle the technicalities appeal is made to a magistrate.

Drum (*Cotton Manufac.*) The hollow cylinder in which steam is applied to printed fabrics in order to fix the colours.

—— (*Eng. etc.*) (1) A large pulley or cylinder round which a belt passes or a rope or chain is wound. (2) A cylindrical chamber used in flues, stoves, and heating apparatus. (3) A cylindrical or barrel-shaped metal vessel (usually of sheet iron, used instead of a wooden barrel for holding liquids or solids, such as oil, paint, white lead, etc.

—— (*Join.*) A cylindrical structure, used in building up various pieces of circular woodwork; a large drum is also used for supporting a number of bars of wood, of square section, which are arranged round its periphery and turned in a lathe in order to form balusters (*q.v.*)

—— (*Lace Manufac.*) A cylinder of wood or tin, about 18 in. in diameter, upon which are wound threads, varying in number from 60 to 120. This forms a supply for winding the brass bobbins. The utility consists in the equal amount of tension obtained.

—— (*Music*). *See* BASS DRUM, KETTLE DRUM, SIDE DRUM, *under* MUSICAL INSTRUMENTS.

Drumming (*Leather Manufac.*) A process frequently employed is to place leather in large rotating drums containing tan liquor, grease, dye, or weighting materials, as required. This treatment is known as "drumming."

Drum Washer (*Paper Manufac.*) A hollow cylindrical vessel, covered with wire gauze, used for removing dirty water from pulp.

Drum Weir (*Civil Eng.*) A WEIR or DAM (*q.v.*) with a gate hinged so as to rotate about a horizontal line. The hinge lies in the plane of the river bed, the lower half of the gate moving in a hollow or drum of quadrant shaped section situated below the level of the river bed. The height of the water in the channel above the weir can be controlled in a very perfect manner by turning the gate or sluice through an angle, so as to raise or lower the "sill" or top edge, thus lessening or increasing the volume of water passing over.

Drum Winding (*Cotton Manufac., etc.*) A system of winding yarn on to bobbins, or in the form of cheeses, by means of frictional contact with drums. Two methods are employed, STRAIGHT and QUICK TRAVERSE. *See also* WINDING.

—— (*Elect Eng.*) *See* ARMATURES.

Drunken Saw (*Carp., Eng., etc.*) A circular saw whose plane is not at right angles to the axle; it is used for cutting a groove in timber, the width of the groove depending on the angle at which the saw is set. Now usually superseded by a thick saw, set square on the axle, which cuts an accurate groove of its own thickness.

Drupe (*Botany*). The "stone fruit" as seen in the plum, cherry, peach, etc. The pericarp, or fruit wall, is in three layers: the rind (EPICARP), the pulp (MESOCARP), and the stone (ENDOCARP). The kernel of the stone is the seed.

Drusy Cavities (*Geol.*) Small cavities occurring in eruptive or other rocks, commonly lined with crystalline minerals.

Dry Area (*Build.*) An enclosed space round an external wall, the bottom of which is below the ground level.

Dry Brush (*Moulding*). A brush used to remove sand or dust, as distinguished from one used to damp the surface of the mould.

Dry Bulb Thermometer (*Meteor.*) *See* HYGROMETERS.

Dry Cells. *See* CELLS, PRIMARY.

Dry Copper (*Met.*) *See* COPPER.

Dry Dock (*Civil Eng.*) *See* DOCKS.

Drying Cylinder (*Paper Manufac.*) A hollow iron cylinder heated internally by steam, used for drying paper.

Drying of Paint (*Dec.*) Oil paint dries or becomes hard partly by absorbing oxygen from the air, which combines with the linseed oil, and partly by the evaporation of the volatile spirit turpentine (*q.v.*) To assist in the oxidation, driers (*q.v.*) are sometimes added, but this is unnecessary in the case of some pigments, such as red lead. With the object of facilitating the drying of newly applied paint, fires or gas jets are sometimes lighted. This is, however, worse than useless, as the heat does not assist the drying, but retards it, owing to the oxygen that is used up. When paint or varnish does not dry, but remains sticky, it is a sign that it has been applied to a dirty and greasy surface. *See also* DRIERS.

Drying Oils (*Paint., Dec., etc.*) Those oils which dry or become hard on exposure to the air. LINSEED OIL (*q.v.*) is by far the most important of these, but POPPY SEED OIL, HEMP SEED OIL, WALNUT OIL (*q.v.*), etc., are also used by painters to some extent. The oils of this class are also called FIXED OILS, because they are not changed by distillation.

Drying Room (*Typog.*) A room heated by hot water or steam to a uniform temperature of about 120° F., and employed to facilitate the drying of the printed work.

Drying Stove (*Moulding*). A furnace or oven used for drying CORES (*q.v.*) before placing them in the mould.

Dry Moulding (*Foundry*). Moulding in pure sand instead of in LOAM (*q.v.*)

Dry Pipe (*Eng.*) A perforated pipe placed horizontally inside the head of a steam boiler for drawing off steam from the whole length of the steam space. Sometimes a trough or half-pipe suspended by lugs about half an inch from the top of the boiler shell.

Dry Plate (*Photo.*) A plate carrying a gelatine film impregnated with salts of silver sensitive to light (*i.e.* the bromide, iodide, and chloride). The plate is usually glass, but may be transparent celluloid, which is light, flexible, and unbreakable; occasionally, however, paper is coated with the sensitive film. *See* PAPER NEGATIVES.

Dry Point. *See* ENGRAVING AND ETCHING.

Dry Spinning (*Linen Manufac.*) Flax may be spun wet or dry, the latter giving a softer and more spongy yarn, which suits better for making some cloths. When spun wet, the rove passes through hot water, which softens the gum in the flax and enables it to be drawn out into a finer and firmer thread.

Dry Steam (*Eng.*) Steam unmixed with fine particles of water, but not superheated (*q.v.*); it is really SATURATED WATER VAPOUR (*q.v.*), and begins to condense at once on cooling. *See also* PRIMING.

Dry Uptake (*Eng.*) The lower part of the flue of a marine boiler which is not surrounded by water; *i.e.* the flue is outside the boiler.

Dry Wood. Seasoned wood, free from sap. *See* SEASONING.

"D" Section Tubes (*Cycles*). These are useful for the horizontal bars forming the back forks, extending from the bottom bracket to the back axle, as they help to reduce the width of tread; but they are not in much favour in the latest machines, being inferior in strength to ordinary round seamless tubes.

"D" Trap (*Hygiene*). This trap, so called owing to its likeness to the letter D, is frequently met with in connection with the old "pan container" closet. It is a very bad type of trap, having too many angles and projections, and is not self cleansing.

Dubbing Out (*Plastering*). Forming a moulding in plaster roughly, preliminary to finishing off the work neatly.

Duck (*Linen Manufac.*) (1) A heavy make of plain texture linen cloth which has either a ribbed or a matt appearance according to make. It is also often made in fancy textures for vestings, trouserings, etc. (2) A Cotton fabric having the same appearance is also manufactured.

—— (*Her.*) In heraldry a duck is always called a CANNET, and appears without feet or beak.

——, **Eider** (*Zoology*). *Somateria mollissima* (family, *Anatidæ*; order, *Anseres*). The well known eiderdown is obtained from the nests, where it forms a covering to the eggs. The female bird plucks the down from her body, gradually increasing the amount during the period of incubation.

Ductility. The property of certain metals which allows them to be drawn out into wire; *e.g.* silver, copper, brass.

Ductless Glands (*Zoology*). The term applied to the thyroid, adrenal (suprarenal), pineal, and pituitary glands. The spleen and thymus glands are also included under this term.

Ductor (*Print.*) A duct, trough, or reservoir which holds the ink in a printing machine.

Duet, Duo (*Music*). A composition for two voices or instruments.

Dulcimer. *See* MUSICAL INSTRUMENTS—STRING (BY PERCUSSION).

Dulcite *or* **Dulcitol** (*Chem.*), $CH_2OH \cdot (CHOH)_4 CH_2OH$. Lustrous prisms; melts at 188°; sparingly soluble in water; sweetish taste. It is isomeric with mannitol, and with hydriodic acid gives the same hexyl iodide that mannitol does. With nitric acid it yields mucic acid. It occurs in Madagascar manna, and can be obtained from this and also by reducing lactose or galactose with sodium amalgam. It is a hexahydric alcohol.

Dull. (1) Blunt (in reference to a cutting tool). (2) In the case of metal, at a heat less than that at which the metal is usually forged or cast.

Dulong and Petit's Law (*Chem.*) The product of the atomic weight of an element and its specific heat is constant, *viz.* 6·4. The law only applies to the elements in the solid state. A few elements of low atomic weight and high melting points, such as beryllium, boron, carbon, and silicon, give a value less than 6·4; but in these cases it is found that the specific heat increases with the temperature, so that when the specific heat of these elements is taken at a high temperature the product, atomic weight and specific heat, approaches the normal. The constant 6·4 is often called the atomic heat. This law does not give accurate values for the atomic weights, but it is very useful in enabling a chemist to decide what multiple of the equivalent (*q.v.*) of an element must be taken to obtain the atomic weight, because equivalents can be determined with great accuracy.

Dumas' Measurement of Vapour Density. A method of finding the density of gases and vapours by weighing a flask of known volume which is full of the gas, and making a suitable correction for the loss of weight of the flask and its contents due to the fact that it is weighed in air, *i.e.* adding on the weight of the volume of air displaced by the flask. The gas or vapour must first be condensed, and a small amount of the liquid placed in the flask. The flask is then immersed in a bath at a temperature above the boiling point of the liquid until vapour ceases to issue from the neck. The flask is then sealed up, and the temperature of the bath at the instant of sealing is noted. The weight of vapour which will occupy the volume of the flask at a known temperature is thus found.

Dumfries Sandstones. *See* BUILDING STONES.

Dummy (*Plumb.*) A thick cane with a lump of lead on the end: used for beating out dents in lead pipes.

—— (*Print*). A set of sheets made up to resemble a book, magazine, etc. The object is to convey an idea of the size of a prospective publication, and if details are furnished, of the scope of such publication.

Dundee Sandstone. *See* BUILDING STONES.

Dunes (*Geol.*) A term almost entirely restricted to the hills of sand which occur in maritime regions. Large quantities of sand are stirred up by the waves during storms, and when these waves are driven on to the coast the water flows back to the sea, and sand is left on the shore. Sand reeds and various grasses bind the accumulation together, and thus help it to increase in size. Sanddunes are often important reservoirs of potable water.

Dunite (*Geol.*) A plutonic rock of granitic structure and ultrabasic composition. It consists essentially of olivine, with some pyroxene and iron ore, but with little or no felspar.

Dunlop Tyres (*Cycle*). *See* TYRES.

Dunted (*Pot.*) Dunted ware is practically the same as FLED WARE, the term being a colloquialism common to the Staffordshire potteries.

Duodecimals. The arithmetical processes involved in the multiplication together of feet and inches in finding areas and volumes in the English system of measures.

Duodecimo (*Print.*) A sheet of paper folded into twelve leaves, commonly called twelvemo and written 12 mo.

Duodenum (*Zoology*). The first loop of the intestine after leaving the stomach. It receives the bile and pancreatic juices.

Dupes (*Textile Manufac.*) *See* DOUP.

Duplex (*Watches and Clocks*). A frictional-rest dead-beat escapement, the escape wheel having two sets of teeth: one vertical set for communicating impulse; the other, horizontal, for producing the rests.

Duplex Lathe (*Eng.*) A lathe with two cutting tools acting simultaneously on opposite sides of the work; the tool at the back of the work is inverted. It is of great use in turning long shafts, as it is not only quicker than the ordinary method, but more free from errors due to the springing of the work and chattering.

Duplex Papers (*Paper Manufac.*) Papers coated with a different coloured mixture on either side.

Duplex Telegraphy. *See* TELEGRAPHY.

Duramen (*Botany*). The heart wood or central portion of the stem of a tree. It has lost the power of transference of water, and is harder and darker than the sap wood.

Duresco (*Dec.*) A washable water paint or distemper, having many of the characteristics of zinc white oil paint (*q.v.*) It is made without lime, gypsum, or natural barytes.

Duster (*Dec.*) A brush used by painters for removing dust before applying paint. In London and the southern part of England a round brush is usually employed, but in the north a flat brush is more generally employed. The latter possesses the advantage of being handy to get into corners and the spaces between the balusters on a staircase.

Dust Proof Bearings (*Cycles and Motors, etc.*) A bearing fitted with some form of cover or cap to prevent as far as possible the entry of dust.

Dust Sheets (*Dec.*) Cloths of unbleached sheeting used by painters over furniture, floors, etc., to protect them during repainting.

Dutch Bond (*Build.*) A similar bond to English, excepting that a threequarter brick is used in the STRETCHING COURSES (*q.v.*), and the closer omitted in the heading courses at the quoins. *See* BOND *and* ENGLISH BOND.

Dutch Bricks. *See* BRICKS.

Dutch Clinker (*Build.*) *See* CLINKER.

Dutch Liquid (*Chem.*) Ethylene dichloride. *See* ETHYLENE.

Dutch Metal *or* **Dutch Gold Leaf.** An alloy of 11 parts of copper and 2 parts of zinc. It is one of the most malleable alloys.

Dutch Pink (*Dec.*) A transparent yellow lake pigment, formerly much used by scenic artists and wallpaper manufacturers. When ground in oil it is useful as a glazing colour (*q.v.*)

Dutch School of Painting. *See* PAINTING, SCHOOLS OF.

Duty (*Eng.*) An old system of measuring the efficiency of an engine. It is the number of foot pounds of work performed by the combustion of one bushel of coal. The modern method is to observe the number of pounds of coal per INDICATED HORSE POWER HOUR (*q.v.*)

D Valve (*Eng.*) The common slide valve which has a cross section very much in the form of the letter D.

Dwell (*Print.*) The pause during which a sheet in course of printing is impressed on the type or forme. In the best platen machines this stationary period or dwell is somewhat lengthy.

Dwellings, Sites for and Structural Arrangements of. *See under* SANITATION.

Dyad Elements (*Chem.*) Divalent elements. *See* VALENCY.

Dyas (*Geol.*) A name often used instead of "Permian" for the lower sub-division of the New Red Rocks. In Britain it is most typically developed in the Eden Valley, where it consists of the Magnesian Limestone (and its Plant Beds), which overlies the Penrith Sandstone and its associated breccias. It was formerly known as the Lower New Red, and is again being recognised by that term. Dyas is correlative to Trias, or Upper New Red.

Dyes and Dyeing. Until the middle of the nineteenth century the substances used for producing colours on textile fabrics were mostly derived from the vegetable kingdom, and consisted of the wood, leaves, seeds, etc., of various plants. The discovery by Dr. Perkin, in 1856, of mauve, the first dye derived from coal tar, and the subsequent introduction of innumerable coal-tar dyes due to this discovery, have entirely revolutionised the art of dyeing. The earlier coal-tar dyestuffs usually known as ANILINE DYES yielded mostly bright colours of inferior fastness to light. In 1868, however, followed the synthesis of alizarine, a substance identical with the colouring matter of the madder plant, and yielding extremely fast colours, including Turkey red, on cotton. More recent discoveries have furnished us with the AZO DYES (which have largely displaced cochineal in wool dyeing); a series of colours, commencing with Congo red, which dye cotton direct in one operation, the sulphur dyes yielding fast colours on cotton; and synthetic indigo, identical with INDIGOTIN, the colouring matter of natural indigo. The only vegetable dyestuffs still used to any considerable extent are logwood, and to a gradually lessening degree natural indigo. The coal-tar dyestuffs now at the dyer's command enable him to produce every imaginable colour with almost any desired degree of fastness on every variety of textile material. *Methods of Dyeing:* These may be best explained by attempting a classification of the various dyes based on their application to animal and vegetable fibres. The methods of silk dyeing resemble those for wool, whilst linen and other vegetable fibres are dyed similarly to cotton. Dyestuffs may be divided into those which require a mordant and those which do not. A MORDANT is a substance which, when applied to the fibre in conjunction with a dyestuff, combines with the latter to produce a useful colour. The mordant is usually applied before the dye, as in dyeing a logwood black on wool. The wool is first boiled in a solution of bichromate of potash, and afterwards in a decoction of logwood. In special cases the mordant is applied after the dye; this constitutes the so-called STUFFING AND SADDENING method; or the mordant may even be applied together with the dye, as when a cochineal scarlet is dyed by boiling wool in a single bath with cochineal, a solution containing tin, and oxalic acid. The group of MORDANT DYESTUFFS includes: (1) All the best known natural dyes (with the exception of indigo, turmeric, orchil, and catechu), such as logwood, the red woods (camwood, barwood, sanderswood, brazilwood, peachwood), madder, cochineal, the yellow woods (weld, old fustic, quercitron bark, flavine, young fustic), and Persian berries. (2) ALIZARINE and allied colours, most of which are derived from the coal-tar product anthracene; examples are alizarine, anthrapurpurin, flavopurpurin, alizarine orange, alizarine blue, anthracene blue, alizarine cyanine, anthracene brown, alizarine black, galleïne, coeruleïne, gallocyanine, etc. All these mordant dyestuffs have in themselves no colouring power, but when used in conjunction with a mordant they produce colours which vary according to the mordant employed. The most usual mordants are salts containing one of the metals chromium, aluminium, tin, copper, or iron. If five pieces of woollen cloth are boiled respectively in solutions of potassium bichromate, aluminium sulphate, stannous chloride, copper sulphate, and ferrous sulphate, and then dyed with alizarine, they will be coloured respectively bluish red, bright red, orange, dull violet, and deep violet. As a rule aluminium and tin mordants give the brightest colours, copper and iron the deepest, while chromium occupies an intermediate place. By far the most largely used mordants for wool are the bichromates of potash and soda; by boiling wool for an hour in a solution of one of these salts alone, or with small additions of acids or acid salts, it acquires the property of subsequently fixing any of the mordant dyes. The mordanting of silk and cotton is more difficult, especially the latter, which usually involves several operations; as a rule the solutions are applied cold or lukewarm. In one method of dyeing Turkey red on cotton, for example, the material is steeped successively in baths containing sulphated castor oil ("Turkey red oil"), basic sulphate of alumina, and chalk, the first two operations being usually repeated several times. Then follow dyeing with alizarine, a further treatment with oil, steaming, and soaping. Tannin is used as a mordant for cotton when dyeing with the basic colours. In this case the cotton is steeped for several hours in a solution of tannic acid or in a decoction of myrabolams, sumach, divi-divi, or other tannin matter, which is then fixed on the fibre by passing through a solution of an antimony or tin salt. The NON-MORDANT DYESTUFFS may be subdivided into ACID, BASIC, and DIRECT COTTON COLOURS. The BASIC DYES are applied to wool and silk by merely immersing the material in the hot colour solution; they are now seldom used for wool. Cotton is mordanted with tannin, and then dyed at a temperature below the boiling point. Except for the brightest colours, they have been largely replaced

by the direct dyes. Examples of this group are magenta, safranine, Bismarck brown, chrysoidine, auramine, malachite green, Victoria blue, methylene blue, methyl violet. The ACID DYES are dyed on wool and silk, with the addition of sulphuric or acetic acid to the dye bath; for cotton dyeing they cannot be used. For woollen piece goods they find a wide application, and are preferred in all cases where only a moderate degree of fastness is demanded and a rapid and simple method of dyeing is the chief consideration. Several hundred dyes of this class are known, including the azo scarlets (grocein, wool scarlet, etc.), naphthol yellow, picric acid, acid magenta, acid violet, fast red, cloth red, naphthol black, alkali blue, soluble blue, etc. A subdivision of this group comprises the EOSINE COLOURS, which yield bright pinks fast to washing, but very fugitive to light. They are dyed on wool with the addition of acetic acid, and occasionally on cotton in a concentrated bath containing common salt. The chief dyes of this class are eosine, erythrosine, phloxine, rose bengale, and rhodamine. The last named is somewhat faster than the rest, and may also be applied to cotton on tannin mordant. The ACID MORDANT DYES for wool are applied by first boiling the wool in an acid bath with the colour, and then adding the mordant to the same bath, and continuing to boil for some time longer. Such are the acid alizarine, anthracene acid, palatine chrome dyes, diamond blacks, etc. The DIRECT COTTON COLOURS or SUBSTANTIVE DYES, also known as the BENZIDINE COLOURS, are dyed on vegetable fibres in a boiling bath, to which is added salt or sodium sulphate, sometimes also carbonate of soda. In certain special cases the colours may be rendered faster to light or washing by an after-treatment with a metallic salt, *e.g.* copper sulphate. Certain direct dyes, *e.g.* primuline, may be converted after dyeing into other colours, possessing greater fastness than the original, by treating the dyed cotton with nitrous acid ("diazotising"), and then passing into a solution of certain phenols or amines, *e.g.* betanaphthol. The direct colours also number many hundreds. Bensopurpurine and chrysophenine are typical dyes of this class. Others bear names with the prefixes diamine-, Congo-, benzo-, direct-, cotton-, oxamine-, pyramine-, Columbia-, Titan-, etc. The SULPHUR or SULPHIDE DYES resemble the direct colours, but require the addition of sodium sulphide to the dye bath, and mostly yield colours fast to light, washing, and acids. They are distinguished by various prefixes: immedial-, katigen-, kryogen-, pyrogen-, vidal-, thionol-, cross dye-, sulphur-, etc. The older dyestuff, cachou de Laval, also belongs to this group. Of the non-mordant natural dyestuffs ORCHIL is dyed on wool with or without an acid, TURMERIC dyes all fibres without addition, and CATECHU is dyed without addition, and the colour developed by a boiling solution of bichromate or copper sulphate. Indigo extract, prepared by dissolving indigo in sulphuric acid, is an acid dye. Outside the groups enumerated remain a number of dyes which cannot be classified; of these the chief is INDIGO, including both the natural product, prepared from the indigo plant by a process of fermentation, and synthetic indigo, derived from coal tar. Indigo is applied to both animal and vegetable fibres in so-called indigo vats, in which the insoluble blue colouring matter is reduced to a colourless body, indigo white, and in this condition brought into solution by the addition of an alkali. The reduction may be brought about by purely chemical means or by fermentation. In the former case we have the bisulphite or hydrosulphite vat used for both wool and cotton, containing indigo, bisulphite of soda, zinc, and lime or caustic soda, and for cotton the zinc lime and copperas vats. Fermentation vats are in this country only used for wool, the woad vat, which contains indigo, woad, bran, madder, and lime, being the most important. For wool dyeing the temperature of the indigo vat is about 120° F.; cotton is dyed cold. After making up the vats the sediment is allowed to settle, and the material is then dyed in the clear greenish-yellow liquor. The goods as they come from the vat are green in colour; by the oxidising action of the air indigotin is regenerated, and they are dyed blue. The colour possesses great fastness to washing, acids, alkalis, etc., and in medium and dark shades is very fast to light. Indanthrene and flavanthrene, two colours of recent introduction, are dyed by a process resembling the bisulphite vat for indigo, and yield respectively blue and yellow colours of exceptional fastness. ANILINE BLACK is the fastest black known for vegetable fibres; it is an insoluble black pigment produced by the oxidation of aniline on the fibre. This may be brought about by working the cotton, etc., in a bath containing aniline, a mineral acid, and an oxidising agent. The presence of small quantities of salts of certain metals, *e.g.* vanadium, has a very favourable influence on the development of the black. Sometimes dyeing takes place in a cold solution, and the black is afterwards developed by steaming or ageing. If not well dyed, aniline black tends to rub off and to become green on exposure to acid vapours. PARANITRANILINE RED: Certain azo dyes may be produced on the cotton fibre by successively steeping in solutions of the different constituents of the colour. The best known dye of this class is paranitraniline red, produced by impregnating the cotton with betanaphthol, drying, and developing in a solution of diazotised paranitraniline. MINERAL DYES: These are now seldom used in dyeing, though still to some extent by the calico printer. They are Prussian blue, produced on cotton by successive treatment with prussiate of potash and iron salts, and on wool by decomposition of prussiates with mineral acids,—chrome yellow and orange (lead chromate); manganese brown (manganese hydroxide); and iron buff (ferric hydroxide). The MACHINERY employed in dyeing varies from a simple pot or tub, in which the material is stirred with a pole in the mordant or dye solution, to machines of greater or less complexity, in some of which, *e.g.* the OBERMAIER MACHINE, for loose wool, the material remains fixed in one position throughout the various operations, and the liquids are circulated through it. The choice of vessel depends on the nature of the material and at what stage of manufacture it is to be dyed. Wool may be dyed as loose wool, yarn, or pieces, also as slubbing, an intermediate form between loose wool and yarn; cotton as loose cotton, cops, yarn (warp or hank), or pieces; silk chiefly as yarn, occasionally in the piece. In selecting the dyes to be applied, not only the nature of the material must be considered, but also the purpose for which the finished goods are intended; and, taking this into account, dyes will be chosen according to their fastness to light, washing, and the finishing operations which the goods may undergo, *e.g.* milling, steaming, hot pressing, etc. For loose

wool very fast dyes are usually selected, since during the operations of manufacture into cloth the colour will be subjected to the destructive influences of light, scouring, and so on. An indispensable condition for satisfactory dyeing is that the material shall be previously thoroughly cleansed from natural or added grease and other impurities. The dyeing of UNION FABRICS, *i.e.* those containing fibres of different kinds, such as wool and cotton, wool and silk, etc., offers considerable difficulty; but by suitably combining the methods applicable to the simple fibres, it is possible to produce on a fabric containing the textile fibres in any combination either plain colours or effects dependent on each fibre being dyed a different colour. The correct combination of processes to achieve these results calls forth all the resources of the dyer's art. R.B.

Dyke (*Civil Eng.*) A barrier of masonry, earth, timber, etc., used to keep back floods, high tides, etc.

—— (*Geol.*) A term which originally meant a dividing line between two contiguous parts of a territory; hence applied to faults which dislocate parts of a coalfield, *e.g.* the Ninety Fathom Dyke in Northumberland. In geological descriptions the term is restricted to the more or less vertical sheets of intrusive rock which have consolidated from a fluid state, and now form wall-like masses in the country rock. Such dykes are generally replacive in their mode of occurrence; they may consist of eruptive rocks of any composition.

Dynamical Equivalent of Heat. It is found by experiment that one caloric, if entirely converted into work, would yield very nearly 42,000,000 ergs. Expressing the same result in engineers' units, we find that the heat necessary to raise 1 lb. of water through 1° F., if entirely converted into heat, is equivalent to 778 foot pounds.

Dynamic Metamorphism (*Geol.*) The mechanical (or mechanico-chemical) effect produced upon rock masses of any kind by movements of the Earth's crust acting under considerable vertical pressure. Usually the movements which give rise to this effect have taken place within the core of great masses whose upper surfaces have been bulged into uplands out of which mountains have afterwards been carved. Dynamic metamorphism usually takes the form of shearing, due to the differential movement of one part of the rock affected with regard to another part. All true SCHISTS (*q.v.*) are rocks which have been affected by these shearing movements.

Dynamics. The theory of forces which are not in equilibrium, as distinguished from STATICS (*q.v.*)

Dynamite. A mixture of an infusorial earth called Kieselguhr (*q.v.*) with nitroglycerine. The mixture is made by hand, and it contains about 75 per cent. nitroglycerine. The Kieselguhr is nearly pure silica (98 per cent. SiO_2). Varieties of dynamite are known as COLONIA, HERCULES, and VULCAN, all of which contain mealed gunpowder in addition to nitroglycerine. GIANT POWDER contains sodium nitrate, resin, and sulphur, as well as nitroglycerine and Kieselguhr.

Dynamo. A dynamo is a machine for converting mechanical into electrical energy. The types of machine by which this conversion has been accomplished are very diverse; but of recent years the evolution has been toward a few distinct types, the differences between which are chiefly dependent upon the various forms in which the electrical energy is required. These forms may for practicable purposes be classified as follows: I. Continuous current; II. Single phase alternating current; III. Polyphase alternating current. I. THE CONTINUOUS

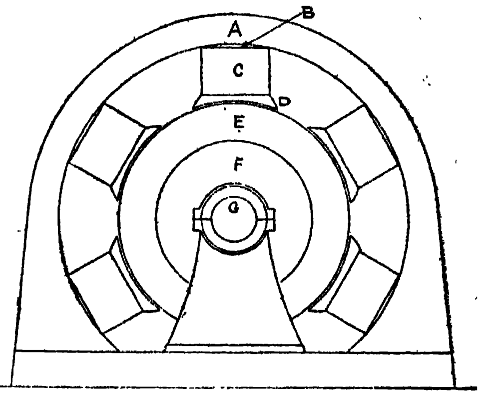


FIG. 1.—CONTINUOUS CURRENT DYNAMO (6 POLE). ELEVATION. FIRST VIEW.

CURRENT DYNAMO: A type of continuous current dynamo is shown in fig. 1. A stationary ring A of cast iron or steel carries a number of salient poles of wrought iron or steel B, each of which is provided with a field coil C of insulated copper wire. Each of the salient poles B terminates in a pole shoe D, and within the cylindrical space limited by the internal faces of the pole shoes an armature E and commutator F are revolved by means of mechanical energy applied to the shaft G, on which E and F are mounted. The armature E consists of a suitable

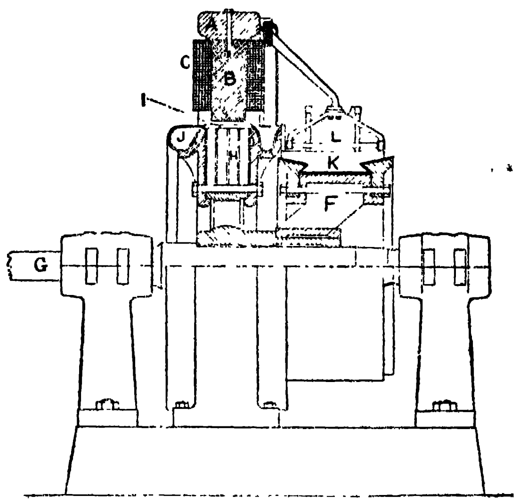


FIG. 1.—SECTION THROUGH POLE, ARMATURE, AND COMMUTATOR. SECOND VIEW.

spider carrying a core H of laminated iron or steel, which completes the magnetic circuit for the magnetic flux flowing through A and B in virtue of the magnetomotive force imparted to the field coils C by a continuous current sent through them, either from an independent external source, in which case the dynamo is said to be "separately excited," or from the dynamo itself, in which case it is "self excited." The external periphery of the laminations of which the

armature core is constructed, is provided with slots at I, carrying the armature winding, of which the end connections are seen at J. From suitable points in the armature winding, connections are carried to the commutator segments K. These commutator segments, of which a commutator generally contains a very large number, are flat plates of copper, generally of some such shape as that shown in the figure. These alternate with sheets of mica, which insulate them one from another, and they are further insulated from the commutator spider by suitably shaped cones and cylinders of mica or micanite. Brushes of carbon or copper, carried in suitable brush holders L, are arranged to bear upon the cylindrical surface of the commutator, and from the brush holders suitable circuit connections are made for transmitting the current from the dynamo to the point or points where it is required for lighting, power, or other purposes. In virtue of the revolution of the armature in the magnetic field, electromotive forces are induced in the armature conductors, and the amount of current delivered from the machine is proportional to the value of the resultant of these electromotive forces (*i.e.* to the terminal electromotive force) and to the resistance of the external circuit. The most convenient formula for determining the voltage of continuous current dynamos is $V = 4{\cdot}00\ T\ N\ M\ 10^{-8}$, in which V = the voltage generated in the armature; T = the number of turns in series between the brushes; N = the number of magnetic cycles per second; M = the magnetic flux (number of C G S lines) included or excluded by each of the T turns in a magnetic cycle. V, the voltage, is approximately constant during any period considered, and is the integral of all the voltages successively set up in the different armature coils according to their position in the magnetic field. It will be found that the relative magnitudes of T, N, and M may (for a given voltage) vary within wide limits, their individual magnitudes being controlled by considerations of heating, electromagnetic reactions, and specific cost and weight. The production of the flux M is effected in several ways, the chief of which are as follows:—(1) *Permanent Field Magnets:* The field magnets are built up of plates or layers of hard steel, permanently magnetised in the same way as an ordinary horseshoe magnet. This type is usually termed a MAGNETOELECTRIC MACHINE, and has only been used for medical purposes or as a mere toy until very recently; but it is found to be very convenient for the production of an electric spark for the ignition of the charge in gas and petrol engines, and is now becoming increasingly common. In by far the larger number of dynamos the field is produced by electromagnets, as in the type described above, and these differ among themselves in the manner in which the current is obtained. (2) *Separately Excited Dynamos:* The coils of the field magnets are supplied with current from an independent source. In large electric lighting stations a subsidiary dynamo is often used solely for this purpose, and is termed the EXCITER or EXCITING DYNAMO. (3) *Series Machines* (fig. 2):

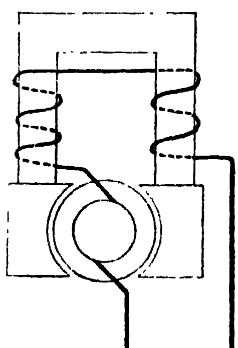


FIG. 2.—SERIES WOUND DYNAMO.

In this form the whole current produced by the machine passes round the coils of the field magnets, which consist of relatively few turns of wire of large cross section. The coils of the field magnets thus form part of the main circuit. (4) *Shunt* or *Shunt Wound Machines* (fig. 3): In these the coils of the field magnets consist of a large number of turns of somewhat fine wire, connected to the terminals of the machine in such a way that a portion of the main current passes round them, *i.e.* the coils form a SHUNT to the main circuit. This is the most usual method of excitation in machines intended for ordinary electric lighting. The method of making the connections for series and shunt machines is shown diagrammatically in figs. 2 and 3.

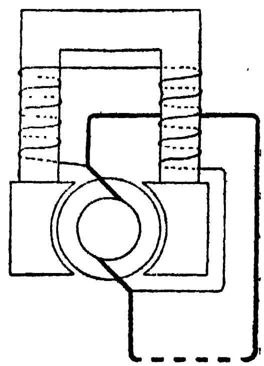


FIG. 3.—SHUNT WOUND DYNAMO.

In fig. 2 the whole current must pass through the field coil, which is in SERIES with the main circuit, while in fig. 3 the field coil forms a SHUNT or alternative path for the current. (5) *Compound Winding* (fig. 4): In this case there are both series and shunt coils. The main current flows through the series coil, but a portion is shunted off through the shunt coil; a decrease in the resistance of the main circuit will then increase the amount of current flowing through the series winding, and therefore increase the magnetisation of the field magnets.

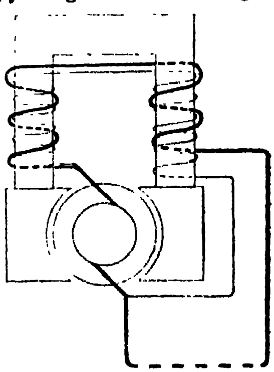


FIG. 4.—COMPOUND WOUND DYNAMO.

By suitably adjusting the series winding, the E. M. F of the dynamo can be kept very constant, even though the resistance of the main circuit vary considerably. (6) *Multipolar Dynamos:* In the earlier days a large per centage of continuous current dynamos were constructed with but two poles.

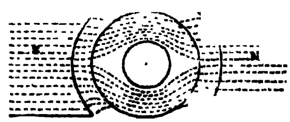


FIG.

With increasing capacities it soon became evident that a bipolar design was unsuitable, and larger numbers of poles were employed. As most dynamos are at present of the multipolar type, the term is now rarely employed. (7) *Nature of the Magnetic Field of a Dynamo:* If the field magnets are excited, but no current is flowing in the armature, the lines of force run as shown in fig. 5, while if the current in

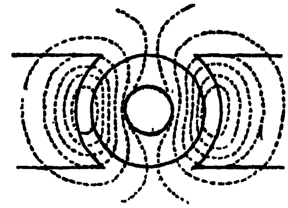


FIG. 6.

the armature were alone flowing, the lines would take the form shown in fig. 6. When the machine is in action, the actual nature of the magnetic field is due to the combined effect of the field magnets and the CROSS MAGNETISATION due to the armature (or ARMATURE REACTION). This is shown in fig. 7. A conductor at A or B is for the moment moving parallel to the lines of force, and not cutting them; hence there is no E.M.F in it at this instant. While a conductor is approaching A (in the direction of the arrow), the current in it is flowing towards the observer, and as the conductor recedes from A, the direction of the current is changed, and it flows away from the observer. The reverse of this occurs at B. The line AB is called the DIAMETER OF COMMUTATION, and the points on the commutator which are in connection with the conductors at A and B are termed the NEUTRAL POINTS. The brushes touch the commutator at these points, and are carried on movable supports, so that the point of contact can be adjusted to follow any variation in the position of the neutral points. In modern dynamos the brushes are by these means set once for all at that position, giving the best results for all loads. The correct position is chiefly dependent upon the magnitude of the reactance voltage, a term of such importance as to justify a brief discussion of its meaning as related to occurrences in the coils short circuited during commutation, and to the occurrences at the brushes. A single armature turn, connected to two adjacent segments, is shown in fig. 8. Prior to coming into the position of short circuit under the brush, it has been carrying a current of, say, 100 ampères in one direction. Immediately after emerging from the position of short circuit, it will be carrying a current of 100 ampères in the other direction. The change must take place sparklessly. With this end in view, the brushes may be set at such a point on the commutator that during the time when the coil is short circuited it will be traversing a magnetic flux of such direction as to tend to reverse the current in the coil. But this tendency must be sufficiently strong to overcome the reactance voltage set up in the coil itself by the decreasing current. This reactance voltage is greater the greater the current in the coil when it arrives at the position of short circuit under the brush; *i.e.* it is greater the greater the load. Hence a stronger reversing field is required the greater the load. At no load a very slight forward lead to the brushes will bring the short circuited coil into a strong reversing field. But at no load no reversing field is required, since there is no current and hence no reactance voltage to be overcome; and if the brushes are given more than a very small forward lead, sparking will ensue in consequence of the current induced in the coil while short circuited, for this current must be broken when the coil leaves the brush, *i.e.* when it emerges from the position of short circuit. At a high load, when a strong reversing field is required to overcome the large reactance voltage, the field has been so distorted by armature interference that a very large lead of the brushes may be necessary in order to bring the short circuited coil into a sufficiently strong reversing field. Hence all that can be accomplished by this so called "electromagnetic commutation" is to choose a brush position as far forward as possible without incurring sparking at no load, and to rate the machine at that load which does not cause sparking in this position, for it is now many years since the practice of permitting different brush positions for different loads has been abandoned. The RESISTANCE of the brush also assists in checking the current originally flowing in the coil. Owing to the unsatisfactory nature of the "electromagnetic commutation," where, as we have seen, the means upon which we rely become weakened in proportion as they should be strengthened, it is sometimes preferable to set the brushes in the geometrical neutral point, and, abandoning all trust on "electromagnetic commutation," merely design the winding with so low a reactance voltage at full load as to preclude the possibility of sparking. (8) *Characteristic Curves:* These are curves showing the relation between the current and the potential difference at the terminals (external characteristic), or the current and the E.M.F. generated in the armature (total characteristic) of a dynamo. They are very instructive and important, and they give a great deal of information about the internal working of the machine. Fig. 9 shows the form of this curve for a SERIES WOUND DYNAMO, the current being plotted along the line OA and the E.M.F. along the line OV. Fig. 10 shows the corresponding curve for a shunt wound machine.

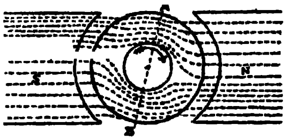
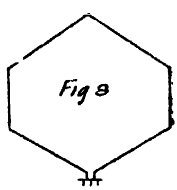
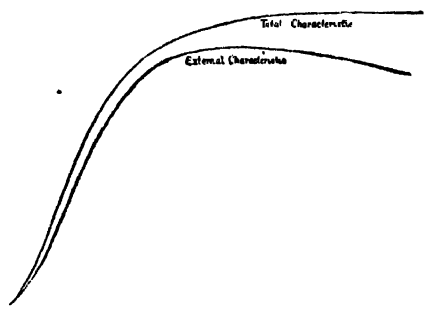


FIG. 7.





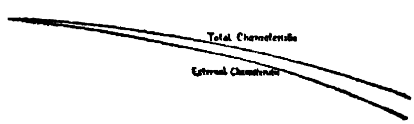


FIG. 10.

The term "Characteristic Curves" is nowadays used in a much wider sense to apply to any curve characteristic of any other feature of the performance of a dynamo. II. THE SINGLE PHASE ALTERNATING CURRENT DYNAMO, *or* ALTERNATOR: If a simple closed circuit be rotated with uniform velocity in a uniform magnetic field, there will be produced in it a varying current whose value at any given instant may be represented by a SINE CURVE (fig. 11). Supposing the coil to be originally at right

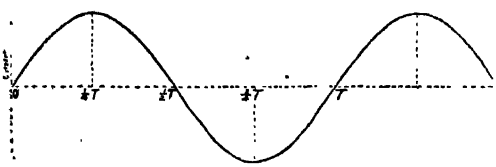


FIG 11.—SINE CURVE.

angles to the lines of force, and to make a complete revolution in T seconds, the changes in the current can be seen from the figure. It commences at 0, rises to a maximum after $\frac{1}{4}$ T seconds, falls to 0 in $\frac{1}{2}$ T seconds, and is then reversed, becoming 0 after T seconds or one complete revolution. In the modern practice T is a small fraction of a second, commonly not over $\frac{1}{50}$, so that each complete change only occupies $\frac{1}{50}$ of a second, and there are 50 complete changes or CYCLES per second. The simplest form of alternator would be a flat coil C (fig. 12) revolving between the poles of a field magnet, which is separately excited. The ends of the coil are attached to two metal rings termed SLIP RINGS, RR, fixed on the shaft, but insulated from it,

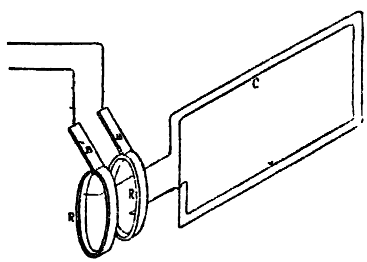


FIG. 12.

and brushes BB collect the current from these rings. The modern commercial machine is, however, of the internal revolving field type, the armature windings being carried on an external stationary ring. III. THE POLYPHASE ALTERNATING CURRENT DYNAMO is now far more widely employed than the single phase alternator. In general construction the two types are identical, except that the external stationary armature carries a number of windings arranged with a given phase displacement from one another. They are generally wound for either two or three phases. The continuous current excitation is carried to the field coils on the revolving field by means of brushes bearing on two slip rings. A machine wound for generating polyphase currents has a much higher capacity than when wound single phase, and is therefore more economical as regards first cost. Polyphase as well as single phase alternators may be, and formerly sometimes were, constructed of the inductor type, in which both the field magnets and the armature coils are fixed. This is

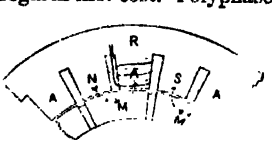


FIG. 13.

shown diagrammatically in fig. 13. Here a large ring of soft iron R has a number of projecting poles, of which those marked A are wound with the armature coils, while N and S are poles of the field magnet, being alternately positive and negative. MM are masses of soft iron rotated by a central shaft. In the position shown lines of force run from the positive pole N to the first armature pole A. As the mass of iron moves to the right the number of lines entering A from N diminishes, until M is immediately under A, when the effect due to N is exactly neutralised by the effect of the negative pole S; as the mass M still moves on, the lines run from A to S, *i.e.* they are reversed. Thus if A be wound with a coil, an alternating current will be produced in this coil. PANCHRONOUS ALTERNATING CURRENT DYNAMOS: All the alternating current dynamos described above must run at synchronous speed. During the last two years there has been independently developed by Latour and Heyland the panchronous type of alternating current generator, in which the revolving field carries a commutator on which are arranged (for three-phase working) three equispaced sets of brushes per pair of poles, three brushes being in conducting connection with the three-phase supply either directly or through transformers. Such panchronous dynamos are self exciting, and while the revolving field is preferably driven in the near neighbourhood of synchronism, as this is the condition corresponding to the best commutation, there is no occasion for the preservation of absolute synchronism, and this feature, together with the feature of self excitation, bids fair to lead to the extended introduction of this class of alternating current dynamo.

Dynamometer, Electrical. An instrument in which the mutual action of two adjacent circuits in which currents are flowing is utilised in order to measure the strength of the currents, or, more exactly, their product, since the mechanical force exerted by one circuit on the other is, generally, proportional to the product of the currents. The principle of the instrument can be illustrated by replacing one pan of a common balance by a flat coil, round which a current can be sent; a second flat coil is fixed to the baseboard of the balance, parallel to and immediately below the first coil. If currents C_1 and C_2 are caused to flow round the two coils, then there will be a force exerted between the two coils proportional to the product C_1C_2. If the direction of the currents be such that this force is one of attraction, it can be balanced by the addition of weights to the other pan of the balance until equilibrium is restored, and the total mass added is proportional to C_1C_2. If the same current circulate round both coils, then the mass added to restore equilibrium is proportional to the square of this current. By an experiment with a known current the value of the constant required to find the value of any current can be found. In SIEMENS' DYNAMOMETER one coil is fixed to the base or stand of the instrument, and the other is suspended, by means of a helical spring or a bifilar suspension, from a torsion head (fitted with a pointer moving over a graduated disc), with the plane of its windings at right angles to that of the first coil. When the current passes, the movable coil tends to turn, and is brought back to its original position by means of the graduated head. The amount which the head is turned is proportional to the couple required to bring the coil back to its original or zero position, and therefore to the product of the currents flowing in the two coils. When the instrument is used to measure a current, the two coils of the instrument are connected in

series, so that the same current flows through both; the instrument then serves as an ammeter. When used as a WATTMETER, or instrument for measuring electrical power (*q.v.*), one of the circuits usually consists of a large number of turns of thin wire, having a high resistance. This circuit is connected as a shunt across the terminals of the apparatus or machine in which the power is to be measured. It therefore receives a current proportional to the potential difference (volts) between the terminals of the machine. The other circuit is of low resistance, and is connected in series to the main circuit of the apparatus, so that the whole current supplying the latter passes through it. The force exerted by one coil of the dynamometer on the other is proportional to the product of the current flowing through the given piece of apparatus and the potential difference at its terminals (amperes × volts), *i.e.* to the electrical power supplied to the apparatus. The dynamometer possesses the great advantage that it can be used for measurements of alternating currents; for if the two coils be so connected that the currents in them are both reversed, the resultant mechanical force between them is unchanged in direction. In measuring alternating current power, however, it is important to ensure that the self-induction of the "pressure" coil, *i.e.* the one in which the current is required to be proportional to the voltage, is kept as small as possible, or, more correctly, that its TIME CONSTANT (*q.v.*) is practically zero. If this is not the case, a lag (*q.v.*) is produced, which introduces a source of error in the measurement.

Dynamo Electric Machines. The older name for the DYNAMO (*q.v.*)

Dynamometer, Mechanical. A mechanical dynamometer is an instrument for measuring the mechanical power which is being transmitted to or from a machine in motion. (1) ABSORPTION DYNAMOMETERS: These absorb entirely the power they receive, usually converting it into heat, which is dissipated into the atmosphere. They are commonly known as BRAKE DYNAMOMETERS, as they depend upon the application of a kind of brake to a rotating wheel, such as the flywheel of an engine, whose actual output of power (termed the BRAKE HORSE POWER) has to be measured. In fig. 1, A is a rotating flywheel, over which passes a belt or band carrying at one end a large weight W, and at the other end a small weight w, or else a spring balance attached to the floor. When the wheel rotates in the direction of the arrow, it will be found that a considerable weight W can be supported in the air with the application of very little force at w. The wheel is then doing work at the same rate as if it were raising a weight $W - w$ by means of a rope coiled round its circumference. If $F = W - w$, and n = the number of revolutions per minute, r the radius of the wheel in feet, then the work done per minute is $F.2\pi rn$ foot-pounds, and $\frac{F.2\pi rn}{33,000}$ is the BRAKE HORSE POWER which the flywheel A is capable of giving out. The belt is often replaced by a thin steel band, the inside of which is faced with wooden blocks which bear on the surface of the wheel. A modification of this form of dynamometer is termed the PRONY BRAKE.

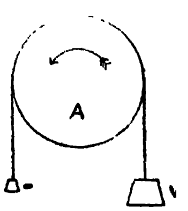


FIG. 1.

(2) TRANSMISSION DYNAMOMETERS: The power transmitted by a rotating shaft is equal to the turning moment or torque multiplied by the angular velocity ($2\pi n$). As the angular velocity is easily measured by a Speed Indicator (*q.v.*), we can find the power if we have any method by which we can measure the torque. An instrument for doing this is known as a TRANSMISSION DYNAMOMETER. The principle upon which one form of this instrument depends is indicated diagrammatically by fig. 2. The power is being transmitted by a shaft A to a parallel shaft B in line with it. To each of these shafts is fixed a radial arm C and D (or discs equivalent to these arms), and these are connected by a spring E, through which the actual force is transmitted. When one shaft is transmitting a torque or a couple to the other shaft, there will be an extension of the spring E; and if this is measured, we can determine the actual torque. Another method of measuring the torque is sometimes applied to electrical motors or small dynamos. It consists in suspending the whole machine bodily in a "cradle" or support carried on knife edges, which are in a line with the axis of the shaft. If a torque be applied to the shaft of the motor while it is running, the whole machine will tend to swing out of the perpendicular, and the moment of the couple required to bring it back to a vertical position can easily be found. This moment or torque is thus equal to the torque applied to the shaft, and therefore the power transmitted to the dynamo is easily calculated. Transmission dynamos are also constructed for measuring tension in a belt. If we can take the difference in tension between the tight or driving side and the loose side of a belt, and multiply this by the velocity of the belt in feet per minute, we shall obtain the power which the belt is transmitting. The velocity of the belt is easily determined from the speed of the pulleys, and the dynamometer has then merely to measure the tension. Two typical ways of doing this are as follows —THE HEFNER-ALTENECK DYNAMOMETER (fig. 3) A and B are two pulleys, one of which is transmitting power to the other. A frame E carries two small pulleys C and D, which can be moved nearer together or farther apart. The frame is placed in such a position that the parts of the belt on both sides of the frame make equal angles with a line through the centres of A and B. The force p, required to keep the frame in this position, is then found. Let T_1 and T_2 be the tensions of the tight and loose sides of the belt; then $p = \sin\theta\,(T_1 - T_2)$; or, if θ is small, $p = \theta\,(T_1 - T_2)$. Hence, by measuring p and θ, $(T_1 - T_2)$ can be found. Another form, due to THORNEYCROFT AND FROUDE, is shown in fig. 4. A pulley A is transmitting power to a pulley

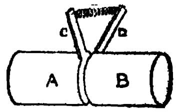


FIG. 2.

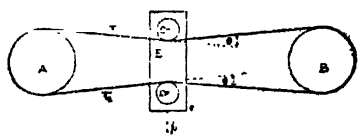


FIG. 3.

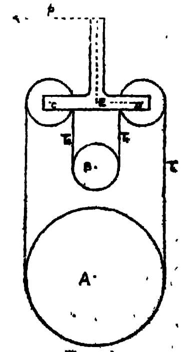


FIG. 4.

B. The belt is caused to pass over two small pulleys whose shafts are fixed at C and D to a frame EF. Then if T_1 indicate the tension on the tight side of the belt, and T_2 the tension on the loose side, the frame E will obviously be pulled over towards the right side, unless a force p be applied to keep it upright. It can easily be shown that $P = 2\frac{ED}{EF}(T_1 - T_2)$, and from this the difference in tension in the tight and loose sides is found at once; and it only remains to determine the speed of the belt to obtain the power which is being transmitted from A to B.

Dyne. The unit of force in the Centimetre Gram-Second System (C.G.S. System). It is the force necessary to give a mass of 1 gram an acceleration of 1 cm. per second per second. It is thus a little more than the force exerted by the earth on a mass of one milligram.

E. The third note of the scale of C.

—— (*Phys.*) The symbol for the COEFFICIENT of SIMPLE ELASTICITY or YOUNG'S MODULUS (*q.v.*) Also used (less frequently) for certain other coefficients of elasticity, for electromotive force, etc.

Eagle (*Her.*) The eagle is generally borne "displayed" (*e.g.* Prussia) or "with wings displayed" (*e.g.* United States), and with beak and claws of a tincture different from the body. When more than one appears upon a shield they are called eaglets.

Ear (*Eng.*) A projecting part through which pass bolts or other fastenings; more commonly termed a LUG.

—— (*Plumb.*) The projection on a pipe by which it is fixed to the wall; used for rain water pipes, waste and soil pipes, etc.

Early English (*Architect.*) One of the periods into which English Gothic architecture is divided. The Early English period extended from about 1189—1307 A.D. The following are some of the characteristics of Early English work: (1) Deeply undercut mouldings. (2) Extensive use of the tooth ornament. (3) Lancet shaped windows and plate tracery. (4) Foliage of a conventional character, usually having stiff stems, and known as stiff leaf foliage. (5) Detached shafts used in the pillars. *See* DECORATED *and* CURVILINEAR.

Earring. A ring, often of precious metal, adorned with gems, worn suspended from a hole bored in the lobe of the ear. The practice of wearing earrings has been common to almost all nations, and amongst many Oriental people they were formerly worn by both sexes. During the reigns of Elizabeth and James I. it was the fashion for men to wear earrings in this country, and the custom still prevails to a limited extent amongst sailors in our own day.

Earth (*Elect.*) From the electrician's point of view the earth is a conductor whose potential is always zero. Any two points in an electrical system which are connected to the earth are therefore regarded as being connected together; hence the earth is utilised in many cases as part of an electrical circuit, *e.g.* in telegraphy, when the earth commonly forms a return wire, and to a certain extent in electric traction, when the return circuit is formed conjointly by the rails and the earth.

Earth Closets. *See* CLOSETS, EARTH.

Earth, Density of. The average density of the earth is found to be 5·5268 times that of water. As this is far higher than the average density of the portion of the earth's crust known to us, it follows that the central portions must have a very much higher density than the outer layers. It has been suggested accordingly that the central part of the earth consists of a mass of the heavy metals.

Earthenware (*Pot.*) The term applies broadly to all pottery which remains, after burning, of an earthy character. It is applied especially to white or cream coloured wares used for inexpensive services. The chief characteristics of earthenware are: softness of glaze; opacity of body, even when made very thin: porosity and absorbency. It is easily chipped and not very durable. *See article* POTTERY AND PORCELAIN.

Earth, Form of (*Astron.*) The earth is an oblate spheroid, *i.e.* a solid produced by the revolution of an ellipse about its shorter or minor axis. The polar semi-diameter (distance of pole from centre) is 3,950 miles, and the equatorial semidiameter is 3,963 miles.

Earth Inductor (*Elect.*) A flat coil which can be turned or spun round about an axis in its own plane. When it is so turned, an electromotive force is induced in the coil by the cutting of the lines of force due to the earth as the coil turns. If the ends of the coil be connected to a ballistic galvanometer, then the throw of the needle is proportional to the number of lines cut by the coil. By observing the throw when the coil is spun through half a revolution, first about a vertical axis, and then about a horizontal axis, a comparison can be made between the horizontal and vertical components of the earth's field.

Earthquake. The violent shock produced at the surface of the earth as a result of the sudden conversion of subterranean water into high-pressure steam. The detonations give rise to a series of wave-like tremors, which progress outwards in all directions from the locality within the earth's crust where the explosions have taken place. A point at the surface directly over this is called the EPICENTRUM, and it is there that the effect first reaches the surface. From that point outward the shocks reach the surface later, and with diminishing effect proportionate to their distance from the epicentrum.

Earth's Field (*Elect.*) The magnetic field (*q.v.*) due to the earth, which behaves as a large magnet. The total intensity is ·438 (dynes per unit pole); the horizontal intensity, ·184; the inclination or dip, 67° 9′, in London. The variations of these "magnetic elements" at different places are shown by maps. *See* ISOGONAL *and* ISOCLINAL LINES, *etc.*

Earthshine (*Astron.*) Near the time of new moon the whole disc is easily visible, the portion on which the sun does not shine having a reddish hue. This light is earthshine, the earth as seen from the moon being then fully illuminated by the sun.

Earth Wax (*Chem.*) OZOKERITE (*q.v.*)

Earthwork (*Civil Eng.*) A general term for cuttings, embankments, etc. In military engineering applied to fortifications constructed by excavation and by the use of the materials so obtained.

Earthy Cobalt (*Min.*) A variety of WAD (*q.v.*) containing a variable quantity of oxide of cobalt. It is a black pulverulent mineral. Cornwall, Leadhills, Saxony, Bohemia, and Missouri and other places in the United States.

Easel. A frame for supporting a picture while being painted; also used for supporting blackboards, etc. A light portable kind of easel used by artists is known as a SKETCHING EASEL.

Easel Picture, Easel Piece (*Paint.*) A picture of comparatively small size, *i.e.* small enough to rest upon an easel whilst being painted. Such pictures are generally highly finished, and admit of close inspection.

Easing Motion (*Cotton Manufac.*) A means of easing the weight on the counter faller of mule, and therefore on the threads.

—— (*Textile Manufac.*) Motions adopted in leno and gauze weaving for slackening or releasing the warp during the formation of what are termed "cross sheds."

Eau de Cologne. A perfume distilled from a mixture of the oils of bergamot, neroli, cinnamon, cloves, lemon, and rose, tincture of musk, alcohol and water. Rosemary and cardamoms are also used sometimes.

Eau de Javelle. An old name for a bleaching solution containing potassium hypochlorite, obtained by passing chlorine into a solution of caustic potash.

Eau de Luce. A remedy for snake and insect bites made from a mixture of mastic spirit, oil of lavender and ammonia; or from oil of amber, alcohol, and ammonia.

Eau Forte. The French term for an etching. Literally, the term applies to nitric acid, with which etchings are generally "bitten."

Eaves (*Build.*) The lower edge of a sloping roof.

Eaves Course (*Build.*) *See* DOUBLING COURSE.

Eaves Gutter (*Build.*) The gutter along the eaves or lower margin of a roof.

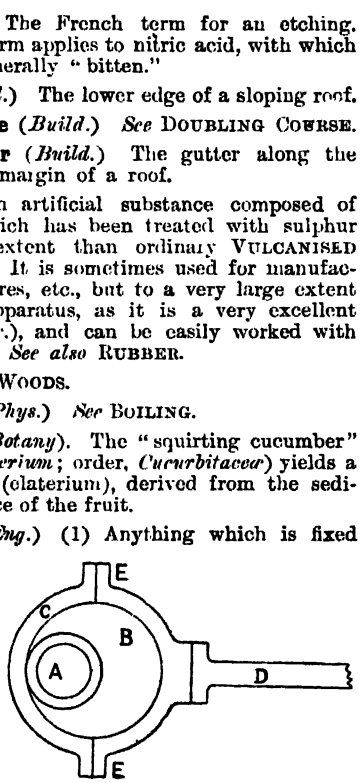
Ebonite. An artificial substance composed of indiarubber which has been treated with sulphur to a greater extent than ordinary VULCANISED RUBBER (*q.v.*) It is sometimes used for manufacturing set squares, etc., but to a very large extent in electrical apparatus, as it is a very excellent INSULATOR (*q.v.*), and can be easily worked with ordinary tools. *See also* RUBBER.

Ebony. *See* WOODS.

Ebullition (*Phys.*) *See* BOILING.

Ecballium (*Botany*). The "squirting cucumber" (*Ecballium elaterium*; order, *Cucurbitaceæ*) yields a purgative drug (elaterium), derived from the sediment of the juice of the fruit.

Eccentric (*Eng.*) (1) Anything which is fixed "out of centre" —*i.e.* which does not rotate about its centre or axis of symmetry. (2) In particular, the disc keyed on a crank shaft "out of centre" which communicates a reciprocating motion to the slide valve, really forming a subsidiary crank. In the figure, A is the CRANK SHAFT, B the ECCENTRIC SHEAVE, C the ECCENTRIC HOOP or STRAP, E the LUGS, D the ECCENTRIC ROD. The distance between the centres of the shaft A and the sheave B is called the ECCENTRICITY or THROW of the eccentric, and equals half the distance the end of the rod D moves, that is, the TRAVEL of the valve.



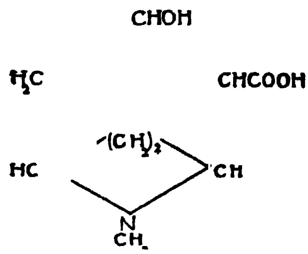
ECCENTRIC.

Eccentric Sheave (*Eng.*) *See* ECCENTRIC.

Eccentric Strap (*Eng.*) *See* ECCENTRIC.

Eccentric Throw Out (*Eng.*) A device for throwing the BACK GEAR (*q.v.*) of a lathe out of action. The back shaft of the gear is carried in collars bored out eccentrically, so that on rotating the collars by means of a suitable handle, the shaft is moved back parallel to itself until the gear wheels which it carries are no longer in contact with those on the mandrel.

Ecgonine (*Chem.*) White solid crystallising in prisms; melts at 198°, with decomposition. Easily soluble in water; less soluble in alcohol; insoluble in ether. It is lævorotatory. It is an acid and also an alcohol. For its preparation and some of its important reactions *see* COCAINE. Besides these may be mentioned the following: Distilled with zinc dust it yields methylamine (CH_3NH_2) and α-ethyl pyridine,



ECGONINE.

CH

HC CH

HC C . C_2H_5.

NH

Oxidised with alkaline permanganate the methyl group (CH_3) is replaced by hydrogen yielding nor-l-ecgonine.

Echinus (*Architect.*) An ovolo moulding enriched with the egg and dart ornament. The ovolo of the Doric capital is also known as the echinus. *See* OVOLO *and* EGG AND DART.

Echo (*Sound*). A sound which is reflected back to the ear of the observer by some large solid object.

Eclipse, Lunar (*Astron.*) When the sun, earth, and moon are in a straight line, or nearly so, the earth acts as a screen, wholly or partially cutting off light from the moon, which is said to be eclipsed. A lunar eclipse can be seen from one half the earth's surface.

Eclipses, Number of (*Astron.*) In one year seven eclipses can occur, either five solar and two lunar, or else four solar and three lunar. The least possible number is two, and these will be solar eclipses. Any series of eclipses recurs after a period of eighteen years eleven days. This interval was known to the Chaldeans, who termed it the Saros.

Eclipse, Solar (*Astron.*) The moon cuts off the sun's light from the earth by wholly or partially obscuring the sun's disc when in a line (or nearly so) between the earth and the sun. The sun is then said to be in a state of total or partial eclipse. If the

dark shadow occupies the centre of the sun's disc, leaving a bright ring all round, the effect is called an annular eclipse.

Ecliptic (*Astron.*) The great circle on the celestial sphere along which the sun's apparent path always lies.

Economisers (*Eng.*) Various types of apparatus for heating the boiler feed water before it enters the boiler, by utilising the waste heat in the flue gases. Generically, any plant which, by economising heat, increases the weight of water evaporated per pound of fuel. *See also* BOILERS.

Economy Coil (*Elect. Eng.*) A CHOKING COIL (*q.v.*)

Ectype (*Art*). An impression of a medal or other object in wax or other plastic substance: a reproduction.

Eddy Currents (*Elect.*) Currents produced entirely within a mass of metal through the movement or alteration in number of the magnetic lines of force passing through it. Eddy currents tend to occur in the cores of transformers, pole pieces of the field magnets of dynamos, etc. They are reduced to a minimum by LAMINATION (*q.v.*) They are often termed FOUCAULT CURRENTS.

Eddy Winds (*Meteorol.*) *See* WHIRLWINDS.

Edge (*Silk Manufac.*) *See* LIZIER.

Edge Coal (*Geol.*) The Lower Carboniferous coal seams of Midlothian happen to occur along a zone where the strata have been thrown into the limb of an earth fold which is steeply inclined. These coals are commercially important, and it is often required to distinguish them from the Upper Carboniferous coal seams which are worked in the same area: hence the name. It is merely a local term.

Edge Runner. A form of mill used for grinding or crushing many materials, such as white lead and other pigments, dry soap, putty, mortar, pulp, paper, etc. It consists of circular stones or rollers mounted so as to run on their edges in a circular hopper or pan, into which is placed the material to be ground. In some forms the pan is stationary and the stones revolve, while in others the pan also revolves.

Edinburgh Wheel. A type of candle-making wheel by which the wicks on the dipping frames could be immersed in the tallow bath in rotation without detaching the frames from the wheel at every dipping. Virtually superseded by the moulding machine. *See also* CANDLE.

Edinol (*Photo.*) This substance belongs to the class of so-called rapid developers, and possesses the advantage over some of them of greater solubility and good keeping qualities. It develops images very free from fog, and is capable of considerable modification to suit various kinds of work.

Edison's Phonograph. *See* PHONOGRAPH.

Eduction (*Eng.*) The EXHAUST (*q.v.*) or leading of the steam, etc., from a cylinder after the stroke is completed.

Eduction Port (*Eng.*) The channel for the escape of the steam, usually termed an EXHAUST PORT.

Edulcoration (*Chem., etc.*) Washing a substance to remove soluble impurity.

Eel (*Zoology*). The eel (*Anguilla vulgaris*) is common to the greater part of Europe.

Effective Current *or* **Voltage** (*Elect. Eng.*) *See* VIRTUAL CURRENT *and* VIRTUAL VOLTAGE.

Effective Heating Surface (*Eng.*) The part of a steam boiler which has water on one side and the fire (or hot gases) on the other.

Effective Span (*Build.*) The horizontal distance between the centres of the bearings of a girder.

Effects (*Chem. Eng.*) The separate vacuum units of a multiple effect evaporator. *See* EVAPORATORS.

Efficiency (*Phys., Eng.*) In general, the ratio between the useful energy obtained from a particular machine and the energy put into it. Thus if power to the amount of 1,000 watts be supplied to a transformer, and 950 watts be obtained from it, the efficiency is 95 per cent., or ·95.

Efficiency of Heat Engines. The efficiency of a heat engine is the ratio of the work done to the heat supplied to it; that is, the fraction $\frac{W}{H}$, where W is the work done and H the amount of heat supplied (W and H must be measured in the same units). If the original temperature of the working substance (steam or other gas) at the commencement of the stroke of a perfect engine be T_1, and at the end of the stroke be T_2, then the efficiency is $\frac{W}{H} = \frac{T_1 - T_2}{T_1}$.

Efflorescence (*Chem.*) Salts which crystallise with water of crystallisation have a definite vapour pressure: when the vapour pressure of such a salt exceeds that of the atmospheric aqueous vapour, the salt, when exposed to air, will lose part of its water of crystallisation; this phenomenon is called efflorescence. The word is also employed in quite a different way to denote the appearance of a white powder on a damp wall or other porous surface.

Effrayé (*Her.*) A horse "salient" or rearing, as in fear.

Effusion of Gases (*Phys.*) The passage of a gas through a porous partition or small opening; the rate of effusion is directly proportional to the square root of the difference of pressure on the two sides of the partition, and inversely proportional to the square root of the density of the gas. *See also* ATMOLYSIS.

Egg and Dart, Egg and Tongue, Egg and Anchor (*Architect.*) A repeating ornament, carved on an ovolo in classical architecture, resembling a series of eggs separated by darts. The Greek egg and tongue, like all other Greek ornament, is much more refined and graceful than the Roman examples.

Eggertz's Test (*Met.*) A colorimetric test for the estimation of combined carbon in steel and wrought iron.

Egg Shell (*Pot.*) Porcelain of extreme thinness and delicacy, originally made in China.

Eggshell Gloss (*Dec.*) *See* BASTARD FLATTING.

Egg Sleeker (*Moulding*). A tool with a rounded face, used for smoothing hollows in a mould.

Egyptian (*Typog.*) A heavy or fat faced style of type (**EH**) now rapidly being replaced by more modern and graceful styles.

Egyptian Blue (*Archæol.*) A crystalline blue pigment used by the Romans. Examples occur in some of the frescoes in the Vatican.

Egyptian Jasper (*Min.*) A banded brown variety of JASPER, an impure opaque form of silica.

Eidograph (*Surveying*). An instrument for reducing drawings to a smaller scale.

Eighteenmo (*Print.*) A sheet of paper folded into eighteen leaves; the same as octodecimo. Usually written 18mo.

Eighth Bend (*Eng.*) A bent pipe whose length is one-eighth of the circumference of a circle; used for joining two pipes which make an angle of $22\frac{1}{2}$ degrees with one another.

Eight to Pica Leads (*Typog.*) Thin leads measuring in thickness eight to one pica, used by printers to put between lines of type to white out or lengthen the printed matter.

Eikonogen (*Photo.*) The sodium salt of amido-β-naphthol sulphonic acid ($C_{10}H_5NH_2OHSO_3Na$). This developer is valuable in portraiture or where soft negatives are required, as well as for snapshot work, and for use with orthochromatic plates. Mixed with hydroquinone it is a favourite with many for general use.

Elæis (*Botany*). A genus of palms, consisting of two species, one in tropical America, the other in Africa. These palms yield a valuable oil. *See* PALM OIL.

Elaidic Acid (*Chem.*), $\begin{matrix}C_8H_{17}\\H\end{matrix}\!>C:C<\!\begin{matrix}(CH_2)_7COOH\\H\end{matrix}$. A white solid melting at 51°. It is isomeric with oleic acid, and is formed from it by the action of nitrous acid; it forms a dibromide, and is reduced to stearic acid by hydriodic acid. Its glyceryl ester is called ELAIDIN, and is formed from olein by the action of nitrous acid, just as elaidic acid is formed from oleic acid.

Eland (*Zoology*). A well known South African antelope, *Orias canna*, whose hide and flesh are valuable.

Elasmobranchii (*Zoology*). A subclass of fishes, comprising the sharks, dogfishes, skates, and rays. They are characterised by a cartilaginous (not bony) skeleton, tooth scales on the skin, absence of a gill cover and swim bladder, etc.

Elastica (*Phys.*) The curve assumed by a uniform strip of elastic material, subject to two equal and opposite forces acting in the same straight line. Also called the ELASTIC CURVE and LINEA ELASTICA. A bent bow is an example of this curve, and various other forms can be obtained by bending a steel wire or watch spring.

Elastic Bitumen *or* **Elaterite** (*Min.*) A soft and elastic hydrocarbon of a brownish black colour, with a peculiar characteristic odour. From Derbyshire, Edinburgh, France, Switzerland, etc.

Elastic Fatigue (*Phys., Eng., etc.*) A falling off in value of the elasticity (*q.v.*) of a body when it has been subjected to a long continued stress or succession of stresses. The effect is very marked when the stresses have been alternately applied and removed. The exact nature of the changes which occur is obscure. There may be definite molecular changes, or the results may be due to the development of minute flaws in the material.

Elasticity (*Phys., Eng.*) That property of matter in virtue of which it offers resistance or opposition to external forces which tend to change its form or dimensions. It is necessary to notice that this definition does not denote quite the same idea as is attached to the word elasticity in ordinary use; for instance, a piece of steel, which offers a much higher resistance to change of shape than indiarubber, is (in scientific language) more elastic than indiarubber.

Elasticity (*Cotton Manufac.*) The amount of stretch or pull the yarn will stand before breaking—a very important factor in warp yarns. Testing machines are employed to ascertain the elasticity and breaking strain.

—— (*Woollen Manufac.*) A term applied to the staple of wool, the yarn, and to the woven fabric.

——, **Coefficient of** (*Phys., Eng.*) The ratio of the stress set up in a body, to the strain which produces it. *See* STRESS *and* STRAIN. Expressed as an equation, this gives

$$\text{Coefficient of Elasticity} = \frac{\text{Stress}}{\text{Strain}}.$$

A coefficient of elasticity is thus equal to the stress which produces unit strain, and is measured in the same units as the stress.

Elasticity of Bulk *or* **Volume Elasticity.** The stress in this case is the increase of pressure per unit area; the strain is the diminution per unit of volume. If a pressure p be applied per unit area of a body, and the volume be diminished by an amount v; then if the original volume be denoted by V, the strain is $\frac{v}{V}$, and we get

$$\text{Coefficient of Bulk Elasticity} = p \div \frac{v}{V} = \frac{pV}{v}.$$

Gases and liquids can only offer resistance to change of volume and not to changes of shape. From the definition of elasticity (*q.v.*) it is therefore evident that they can possess bulk elasticity only.

Elasticity of Compression (*Phys., Eng., etc.*) In the case of simple compression the stress is the pressure applied per unit of area, and the strain is the diminution per unit of length (measured in the direction of the stress). Thus, if a pressure p be applied to the end of a bar of cross section a, the stress is $\frac{p}{a}$. If the original length of the bar be L and the amount of compression be l, then the strain is $\frac{l}{L}$. Then if E be the coefficient of elasticity of compression, we get

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{p}{a} \div \frac{l}{L} = \frac{pL}{al}.$$

This result is similar to that obtained for the elongation of a body (*see* ELASTICITY OF ELONGATION), and the coefficient is in very many cases the same in amount.

Elasticity of Elongation (*Phys., Eng., etc.*) In the case of simple elongation the stress is the stretching force per unit area; the strain is the elongation per unit length. If a bar of length L and cross section a be stretched by a force p till its length be increased by an amount l, the stress is $\frac{p}{a}$ and the strain is $\frac{l}{L}$. Then the coefficient of longitudinal elasticity, or, as it is often called, the value of YOUNG'S MODULUS, for the material is

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{p}{a} \div \frac{l}{L} = \frac{pL}{al}.$$

The value of E is given in units of force per unit of area. For engineering purposes it is usually given

in tons per square inch. The values for some of the most important materials are as follows:

	Tons per Square Inch.	Dynes per Square Centimetre.	
Steel (tempered)	16,000	25	10^{11}
Steel (mild) .	13,200	20·8	10^{11}
Wrought Iron .	18,000	20·5	10^{11}
Cast Iron . .	6,250	9·8	10^{11}
Copper (drawn) .	7,880	12	10^{11}
Brass (wire) . .	6,350	10	10^{11}
Teak	1,070	1·76	10^{11}
Ash	717	1·11	10^{11}
Oak	655	1·01	10^{11}

Elasticity of Flexure. The coefficient of elasticity concerned in the simplest cases of bending is Young's Modulus, or the elasticity of elongation (*q.v.*) *See also* BEAM.

Elasticity of Gases (*Phys.*) The only kind of stress to which a gas can be subjected is the increase of pressure per unit area; the strain produced by this stress is measured by the diminution which each unit of volume of the gas undergoes. The ratio of stress to strain depends upon thermal conditions, *i.e.* whether any heat is allowed to enter or leave the gas during the operation. If no heat enter or leave, the change which occurs is adiabatic (*q.v.*), and the value of the elasticity is then obtained from the adiabatic equation, PV^{γ} = constant. This gives $E = \gamma P$. If the change is isothermal, the ratio is determined by Boyle's Law: PV = constant, and we get $E = P$. Thus in one case the elasticity of a gas is equal to the pressure; in the other case, to the pressure multiplied by γ, which is the ratio of the specific heats (*q.v.*)

Elasticity of Shape (*Phys.*) *See* TORSION *and* RIGIDITY.

Elastic Limit (*Eng.*, *Phys.*) The extent to which a body may be deformed or strained, and still retain the power of completely recovering its original shape when the stress is removed The greatest strain and stress which do not exceed this limit are often termed the ELASTIC STRAIN and ELASTIC STRENGTH of the substance. If the elastic limit be exceeded, the body does not recover its previous form on the removal of the stress, but retains a permanent alteration of form or a "set."

Elastic Packing (*Eng.*) PACKING (*q.v.*) made of rubber covered over by canvas.

Elastic Strain (*Eng.*) *See* ELASTIC LIMIT.

Elastic Strength (*Eng.*) *See* ELASTIC LIMIT.

Elbow (*Eng.*, *etc.*) A short length of pipe bent at a sharp angle.

—— (*Mining*). A sharp bend in a vein or lode.

Elbow Lining (*Carp.*, *etc.*) The framing at the sides of a bay window or recess below the nosing.

Elbow Point (*Print.*) A press point made upon an elbow to facilitate pointing in 12mo or 18mo works.

Elbow Press. A special form of screw press for expressing tallow, waxes, and oils from animal tissue and vegetable products. Intermediate between the old types of lever and wedge presses and the modern hydraulic press.

Elder (*Botany*). The elder (*Sambucus niger*; order, *Caprifoliaceæ*) is of value on account of its fruit, flowers, and the pith. The fruit is made into a wine; the flowers are used in making ointment and a "water." *See also* WOODS.

Electrical Lines of Force. *See* LINES OF FORCE.

Electrical Machine. A device by which charges of electricity can be imparted to objects or differences of potential set up. The name is, however, usually confined to machines consisting of revolving plates (or cylinders) of glass or ebonite, which are electrified by friction (frictional machines) or by induction resulting from a small initial charge. *See* WIMSHURST, VOSS, *and* HOLTZ MACHINES.

Electric Automobiles. A light carriage propelled by a continuous current motor, which is supplied with power by a battery of storage cells. These carriages are very smooth and silent in action, but the great weight of the storage cells prevents them from carrying sufficient power for long runs. On this account they are only suitable for town use as a "Runabout," never moving far from places at which the storage battery can be recharged.

Electric Charge. A definite quantity of "electricity" or of "electrification." Maxwell remarks, "The electrification of a body is a physical quantity, capable of measurement. We are therefore entitled to use language fitted to deal with electrification as a *quantity* as well as a *quality*, and to speak of any electrified body as *charged with a certain quantity* of positive or negative electricity." *See also* ELECTRICITY.

Electric Discharge. The dissipation of electricity or loss of charge from a body. It may be accompanied by visible phenomena, such as sparks, a glowing appearance of the surrounding gas, etc., or it may be of a nature not evident to the senses, and only to be detected by electrical means. *See* DISCHARGE.

Electric Furnace. *See* FURNACES.

Electric Ignition. *See* IGNITION.

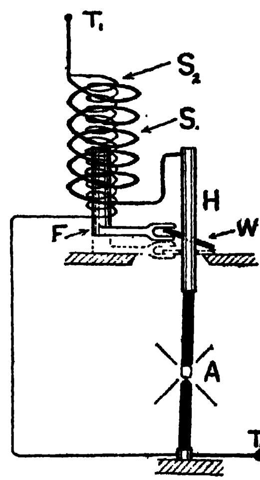
Electric Image. An imaginary electrified point (or system of points) situated on one side of a surface, and producing on the other side the same electrical action which the actual electrification of that surface produces. These imaginary points correspond (to some extent) to virtual images in optics, but their positions are not governed by the same laws.

Electricity. Early writers on the nature of electricity supposed it to be either a fluid of peculiar properties or else two fluids whose properties were complementary to each other or of opposite kinds; for example the ONE FLUID THEORY of Franklin, and the earlier TWO FLUID THEORY of Symmer. Later physicists arrived at the conclusion that whatever electricity might be, it was not a material substance. This theory was based upon many considerations arising from the existing knowledge of the properties of "material substances" or "matter." As an alternative it was suggested that electricity was a form of energy, but this proved untenable. Professor Lodge (now Sir Oliver Lodge) stated, in *Modern Views of Electricity*, published in 1889, that "Electricity may be a form of matter; it is not a form of energy." Since this was published, a vast amount of experimental work has extended our knowledge of the properties of matter under new conditions; these researches include the phenomena connected with the passage of electricity through gases, the various newly discovered forms of radiation, and the investigation of the properties of radio-active bodies. As a result of these researches it has been found by Professor J. J. Thomson that positive electrification is always

associated with ordinary matter, while negative electrification is not necessarily so, but may be associated with bodies very much smaller than the smallest particle of ordinary matter previously recognised, *i.e.* the atom of hydrogen. To these bodies the name CORPUSCLE or ELECTRON has been given. An assemblage of these electrons corresponds to the electric fluid, and a negatively charged body is one to which a number of electrons have become attached. An electric current is a stream of electrons, and a substance which conducts electricity is one through which the electrons can move freely. To account for positive electrification it is necessary to suppose that every neutral or unchanged atom of ordinary matter contains, or is associated with, a definite number of electrons, together with a positively charged nucleus. If this atom be deprived of some of its electrons, it becomes positively electrified; if one or more electrons (over and above the original number) become attached to it, it is negatively electrified. The effective mass of such a charged atom will not be very different from that of the uncharged atom; hence in a gas under ordinary conditions of pressure, the positive and negative ions will not differ appreciably from each other in mass. But when the electric discharge is sent through gases at very low pressures, free electrons are projected from the cathode, and it becomes possible to measure their velocity, and the ratio of the mass of each to its charge. Other methods enable the charge itself to be measured, and as a result it is found to be the same as the charge carried by the hydrogen ion in the electrolysis of solutions; this is $3{\cdot}4 \times 10^{-10}$ electrostatic units, while the mass of the electron is about $\frac{1}{1000}$ of that of an atom of hydrogen. The action of electrons is capable of accounting not only for electrical and magnetic phenomena, but also for many of the well known physical and chemical properties of matter; thus the Mass, Inertia, Valency, the position of elements in the Periodic System, and the character of their spectra can all be referred to the behaviour of electrons attached to or separated from the atom of elements. In addition to these far-reaching results, the phenomena presented by radio-active substances, such as radium, can be traced to the properties of electrons. It must be pointed out that our definite experimental knowledge only applies to *negative* electricity; the nature of positive electricity (and of the positively charged particles projected from Radium) is still absolutely unknown, and the ideas referred to above are merely speculative.

Electricity, Atmospheric (*Meteorol.*) The electrical state of the atmosphere varies in amount; but electrification is always present, and may easily be detected by ELECTROSCOPES (*q.v.*) connected to kites, etc., by a conducting string or wire, as in Franklin's early experiments. The POTENTIAL (*q.v.*) of the air is usually positive. In a thunderstorm there are sudden and violent changes both in sign and potential.

Electric Lighting. The energy of an electric current was first transformed into light by the agency of the "arc" or spark. Humphrey Davy found in 1800 that two touching points in a circuit carrying a current gave a flash on being separated. The brilliant whiteness of the spark produced on separating carbon points suggested the commercial value of this phenomenon, and in 1810 Davy exhibited at the Royal Institution a flame maintained between the ends of two horizontal carbons 4 in. apart. From the shape of the flame—that of a bow or "arc" of light—the name was derived which has since characterised this method of lighting; though, by the now general practice of placing the rods vertically above each other, the distinctive form has disappeared. Arc lamps are constructed for use on both continuous current and alternating current systems. In the latter case the frequency (or number of double reversals of current direction per second) must not be less than fifty, or else the lamps flicker objectionably. They may be grouped "in series," the same current passing through them one after another; "in parallel" or side by side along the feeding circuit, each working independently of the rest so long as the electrical pressure remains steady; or "in series parallel," a number of parallel circuits of lamps in series. In the first class each lamp should have an automatic short circuiting device, so that the breakdown of one lamp does not extinguish the rest. In the second and third classes each lamp should be bridged by an equivalent resistance, to be automatically thrown in if the lamp fails, to maintain the steady burning of the rest. An arc is in a state of unstable balance: if a slight increase be given to the current, the resistance of the arc to the passage of current becomes less, the area of the arc being proportional to current strength, and the current will therefore build itself up indefinitely. Conversely, a diminution of current produces further reduction till the arc goes out. It was therefore speedily recognised that unceasing regulation was necessary, this being performed by adjusting the *length* of the arc. This was at first effected by hand, and for all purposes where the operator is in constant attendance (as with searchlights) this is still done. Automatic regulation was introduced by Wright in 1845, while Staite first used the current itself to regulate the carbons in 1848. The functions of a modern arc lamp mechanism are to separate the carbons (after bringing them together if they do not close by gravity when the current is switched off), to steadily maintain the distance between the carbons so that the illumination is kept constant, to feed one or both carbons towards each other as their ends are burnt away, and after switching off to leave the lamp ready to restart whenever required. The control is effected by balancing the pull of one or more electromagnets in the lamp circuit against gravity, the pull of a spring, or both combined. A typical mechanism for these operations is shown, reduced to its simplest form, in the diagram. The current passes from one terminal T_1 through the series (thick) coil S_1, the top carbon holder H, the two carbons at the junction of which (A) the arc is formed, to the other terminal T_2. The carbons are initially in contact. A strong current, passing through this closed circuit, energises the series coil, which pulls the plunger-piece F upwards.



ARC LAMP.

This has a fork engaging with a washer W, which is a loose fit on the rod holding the carbon. If slightly tilted by the fork, it grips the rod, and if F be further raised, the upper carbon is lifted, striking the arc. A shunt coil of fine wire S_2 also acts on the plunger in an opposite sense to the series coil. If the arc grows too long, *i.e.* its resistance is raised, the current becomes stronger in the parallel shunt coil, weakening the pull on the plunger and allowing the washer to fall back on its support as shown by dotted lines, the rod then slipping till the arc resistance is again low enough. This "differential" winding is essential in series arc circuits, where the current is practically constant whatever fluctuations each arc makes, the series coil simply striking the arc. On parallel and series parallel circuits, though used, it is not essential, a series coil being sufficient. Other mechanical devices are used to feed the carbons, the clutch type being here described for its extreme simplicity. As all control mechanisms have a little inertia, they do not respond instantaneously to sudden fluctuations of current; in parallel circuits, therefore, "steadying resistances" (for direct current arcs) or "choking coils" (for alternating current lamps) must be provided to damp these fluctuations. In series circuits these latter devices are unnecessary, as the dynamo is specially built to take care of the fluctuations. The above adjuncts to the lamp are usually contained in the cylindrical case surmounting it, or, where their bulk is prohibitive, in a wall box or the base of the supporting lamp post. The candle power of an arc varies with the angle to the axis of the carbons at which the measurement is made. In direct current lamps the light is thrown well downwards, giving a maximum at about 60° from the axis. Alternate current lamps throw their light almost equally up and down, and hence must be provided with reflectors. The average candle power (taken from a large number of measurements all round the lamp) of an ordinary street lamp ("open type") is from 525 to 875, the current, if continuous, being from 6 to 10 ampères, or from 10 to 15 ampères if alternating. If the current is less than these minima, the proportion of cooling surface of carbon to energy of the arc is much increased; the arc flickers violently and goes out. An 875 candle power lamp requires about 0·6 horse power, delivered at the carbons. The carbons themselves are gradually consumed by the arc, requiring replacement in eight to ten hours. The arc light is admirably adapted for public lighting, and in the form of Jablochkoff's "candles" was first used for this purpose in 1876 to light the Avenue de l'Opera, Paris, and the Thames Embankment, London. Recent tests by the Westminster City Engineer show that the cost per candle power per annum (including maintenance, sinking fund, and interest) for arc lamps averages 11·76*d.* The best figure for gas (Sugg's high pressure) is 8·7*d.*, and with ordinary incandescent mantles 18·18*d.* In 1894 "enclosed" arcs were commercially introduced, the arc burning within a small globe of clear or opalescent glass, the latter giving a more diffused light, but absorbing about 15 per cent. In some cases this is enveloped by a larger globe. The outside air is largely excluded, and after a few minutes' burning, the arc is surrounded by carbon monoxide, an inert gas. As a result, combustion is slower, the carbons lasting from 100 to 120 hours; the voltage across carbons can be raised to 150, though 80 volts (on 100 volt mains) are generally used; the light changes from white to violet as the voltage increases; the temperature within the globe rises, rendering the cooling surface less effective, and allowing the use of smaller currents. The usual value is 5 ampères, but recently "midget" lamps have been made of sufficiently small power to comfortably light an ordinary room. Efforts have lately been made by mixing salts of metals, such as calcium fluoride and cryolite, with the carbon, to change the colour of the light; the Bremer arc, giving a reddish yellow flare, being the best known example. This lamp is also remarkable as reverting to the true "arc," a flame being projected downwards—*i.e.* in the direction of maximum use—from the carbons (which are each tilted at an angle of 15° to the vertical) by the action of an electromagnet. Almost simultaneously with the practical development of the arc light came the initiation of the glow lamp—an electric conductor raised to incandescence, but not volatilisation, enclosed in a glass bulb in which a very high vacuum is obtained. In 1858 Jobart proposed to use a small carbon in a vacuum, but we owe our present lamp principally to the work of Edison and Swan between the years 1877 and 1880. Platinum wire was first used, but was liable to sudden rupture if overheated. Thin carbon wires prepared from parchmentised cellulose are now employed. The cellulose thread is formed by treating cotton thread with strong sulphuric acid, or by dissolving cotton wool or Japanese paper in zinc chloride, the viscous solution being then squirted through fine jets into alcohol, which hardens the thread. This parchmentised filament is wound on carbon blocks moulded to the required shape, and placed in a crucible packed with plumbago, where it is maintained at a white heat for twenty-four hours. The carbonised filament is next attached to leading-in wires of platinum either by carbon cement or electrically deposited carbon, being then immersed in a liquid or gaseous hydrocarbon (*e.g.* benzoline) and a strong current "flashed" through it, making it instantaneously incandescent. In this state it receives a deposit of hard carbon, which adheres more especially to the thinner (or hotter) parts of the wire, rendering it of uniform thickness. The filament is now sealed (by the leading-in wires) into a glass bulb provided with an extension tube, which is afterwards fused on to the exhaust tube of a mercury air pump. After an almost perfect vacuum is obtained in the bulb the latter is melted off the extension tube and tested for vacuum, candle power, and voltage. The cap which fits the lamp holder is now fixed to the bulb by plaster, and figures for voltage and candle power etched on the glass. Difficulty in standardising the pressure of supply was found, but practice ultimately resolved, itself into supplying at 100 to 110 volts as being most suitable to the lamp's requirements. Of late years, however, lamps have been commercially produced for pressures up to 240 volts, and the importance of this advance is measured by the fact that a given quantity of electricity at 200 volts can be distributed over an area four times as large as that available with 100 volts, with the same loss. The glow lamp is not so efficient as the arc, one 16 candle-power lamp requiring about 0·085 horse-power; but the light is more agreeable, and much smaller lamps can be used, the usual candle power per lamp being 8, 16, or 32. Within the last three years an important departure has been made by the introduction of the Nernst lamp, which is essentially a thin rod of highly refractory earths of rare metals similar to those used in the Welsbach gas mantle. Such a rod is a non-conductor when cold, but on

being moderately heated permits the passage of an electric current, which then renders it brilliantly incandescent. The filament glows safely in air, being merely surrounded by a glass wind shield. A spiral of this wire cased in enamel surrounds the rod, and is in circuit on first switching the current on to the lamp, becoming heated to bright redness and imparting heat to the refractory filament. As soon as the latter is warm enough to conduct the current a small electromagnet switches the heater out of action, replacing it when the current is switched off. The resistance of the rod to passage of current becomes less the stronger the current which heats it, and if left to itself the rod would soon burn out. The current is therefore first passed through a loop of iron wire, the resistance of iron *increasing* the stronger the current flowing through it. By a proper proportioning of the filament and iron, a steady light, and durability of the lamp, are ensured. The average life of the filament, which is replaceable at small cost, is 475 hours. The efficiency of the lamp is very nearly equal to that of the arc; it gives a soft white light, and is obtainable in candle powers of from 50 to 2,000. The cost of burning, including renewals, is approximately 11*d.* per 1,000 candle power hours, as against, say, 15*d.* for ordinary glow lamps.—J. A. S.

Electric Motor. *See* MOTORS, ELECTRIC.

Electric Power. The rate at which electrical energy is supplied or developed. It is proportional to the strength of the current and also to the electromotive force. The unit in which electrical power is measured is the work done in one second by a current of 1 ampère supplied at a potential difference of 1 volt, and is termed the WATT. One watt = 10^7 ergs per second; 746 watts = 1 horse power. When the current is continuous, the power is equal to the product VC, where V is the difference of potential in volts between the terminals of the part of the circuit in which the power is being measured, and C the current, in ampères, flowing through it. C and V are respectively measured by any suitable form of ammeter and voltmeter, the former being joined up in series with the main circuit, and the latter being joined up as a shunt across the terminals. If the current is an alternating one, the power supplied is equal to the product VC cos ϕ, where V and C are the virtual values (*q.v.*) of the volts and ampères, and ϕ is the angle of lag. Alternating current power can be measured by means of a dynamometer or wattmeter, or by certain special combinations of instruments.

Electric Screen. A closed surface of conducting material, connected to earth and therefore at zero potential. An object placed inside such a surface is entirely protected from the action of any external electrified body.

Electric Traction. The history of electric traction in early days is a record of protracted struggle under adverse conditions, but later the record is one of progress and success that is almost unequalled. The date of its inception cannot be rigidly fixed, but the chief landmarks in its history are briefly as follows: The introduction of the underrunning trolley by F. J. Sprague in 1886. The attention given to the design of cars by Brill, resulting, a little later, in the consideration of the truck as a separate and most important part, not subservient to the car body, as was formerly more or less the case. The inception of the SERIES PARALLEL CONTROLLER by Hopkinson, and its improvement by Condict and Thomson into the important piece of switching apparatus that we now know, without which economical electric traction would be impossible, as starting and regulation of speed would have to be performed by the introduction of wasteful series resistances. Improvements in motors, track construction, and other details have, of course, been responsible for a great measure of the present success of electric traction; and as practically all the principal firms have contributed to their gradual evolution, they do not belong to any particular date or name. At the present day the recognised methods of electric traction in practical use are: (1) ACCUMULATOR; (2) SURFACE CONTACT; (3) CONDUIT; and (4) OVERHEAD systems. Of these the last is by far the most popular. The first, in which the motive power is carried on the car in the shape of charged accumulators, may be dismissed in few words. Despite its sundry advantages, such as flexibility and self-containedness, it has been proved to be commercially impossible, owing to its low efficiency and the rapid deterioration of accumulators when exposed to perpetual shaking and jarring. The advent of a lighter, stronger, and more efficient cell is the only thing that can popularise this form of traction. The SURFACE CONTACT system, on the other hand, has possibilities; indeed, several inventors claim to have solved the problem of transmitting power to a moving car, without having overhead or underground conductors. Every few feet down the centre of the track are laid contact blocks, slightly higher than the surrounding road surface; and these are connected through adjacent automatic switches to the feeder cables. On the bottom of the car is carried a collecting SKATE, which, rubbing on the contact studs, conveys the current to the motors, the return path being through the wheels and rails. The essential feature of the system is that the studs should only be alive when directly under the car; it therefore follows that the latter must have an alternate closing and opening influence upon the underground switches, and this is effected, according to the system, either by electrical, magnetic, or mechanical means. Fig. 1 shows a

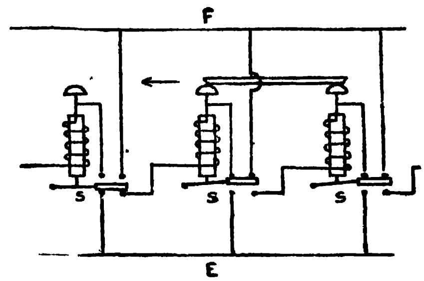


FIG. 1.—VEDOVELLI SURFACE CONTACT SYSTEM.

typical case of electrical working due to Vedovelli: SSS are the automatic switches, F the feeder, and E the earth return. Upon the skate touching a leading stud, the latter is placed in electrical connection with the trailing one; consequently a current flows through the magnetic switch coil of the former, lifting up the switch from the two bottom contacts upon which it rested, closing it as shown, and passes away to earth through the contacts of the next switch of the series. When the skate breaks contact with the stud, the switch opens, as the current that was holding it in position by the aid of the electromagnet is stopped. Magnetic methods are usually

simpler and more reliable than the above. Generally a magnet excited by the line current or a separate battery of cells is carried underneath the car, and this suffices to actuate the stud-switching mechanism. Mechanical operation appears to be the most reliable if the design is good. It may be effected among other ways by a plough running in a shallow conduit, operating the switches by mechanical means as it passes. Surface contact electric traction has of late received an impetus, owing to the introduction of sundry improvements tending towards greater reliability; the consensus of opinion is, however, against it as a system. The CONDUIT system has been proved by large experience to be reliable, provided great attention is paid to its design and construction. It is generally accepted as the only possible alternative to the trolley, but, being costlier and less convenient, it cannot compete upon equal grounds. It has the advantages that it is not unsightly, and affords every facility for an insulated return, which latter is an important point, as it obviates the necessity of bonding the rails, and does away with the usual electrolytic troubles in adjacent pipes consequent upon an earth return. Between the track rails is placed a roomy and well drained conduit, open to the extent of about ¾ in. on top, and built up usually of concrete more or less in the form of fig. 2. Fixed to the walls by the aid of insulators

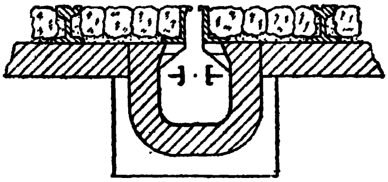


FIG. 2.—SECTION OF LONDON COUNTY COUNCIL CONDUIT BETWEEN YOKES.

are the bare + and − conductors, and between them, passing clear through the slot, runs the collecting plough, picking up the current on the one side by an insulated plate connected to the motors, and returning it by a similar contrivance on the other. In practice, trouble is often experienced in the design and working of crossings and points, and in many cases underground pipes offer a serious hindrance to the construction. The OVERHEAD TROLLEY SYSTEM is, of course, free from such objections, and is consequently very much cheaper to instal and maintain. It derives its name from the fact that originally a small trolley was employed to run on the *top* of the wire, picking up the current, and passing it through a cable to the car; but this was found to be impracticable, and the greatest impetus the overhead system has known resulted from the introduction of the underrunning trolley. In a modified form this is the apparatus used at the present day. Owing to the impracticability of employing two overhead conductors and two trolleys, the current is returned to the power house through the rails, and this calls for the above mentioned necessity of bonding. The Board of Trade regulations with regard to the return circuit are stringent, 7 volts being specified as the maximum allowable drop of pressure over it. In cases where this is exceeded it becomes necessary to instal a negative booster (*q.v.*) in the return circuit of the feeders. Except in special cases where allowance is sometimes made, the Board of Trade rules specify that the speed is not to exceed ten miles an hour, and four miles an hour through facing points; that the overhead conductor is to be electrically split up into sections not exceeding half a mile in length; and that the latter is to be supported, at least every 120 ft., at a height not less than 17 ft. from the ground, except when conveyed under bridges. The electric railway was a natural sequence to the success of the tramway, and is undoubtedly destined to create a revolution in railway operation. Up to the present it has been confined to suburban and short lines, but several important companies have the electrification of their main lines under consideration. In the case of a short line, direct current at a pressure of 500 volts is generated at the power house and fed on to a bare conductor placed adjacent to the track; the return is either through the rails or another special bare conductor. An example of this is the Great Northern and City Railway. The Central London Railway, on the other hand, generates a three phase alternating current at a pressure of 5,000 volts, transforms down in substations, and converts by the aid of rotary converters to direct current at a pressure of 500 volts, and in this form the power is used on the train. There are two distinct methods of electric railway operation in use at the present day, *viz.* the LOCOMOTIVE and the MULTIPLE UNIT system. The former speaks for itself, and its limitations are practically on a par with those of the steam railway; but the second possesses several important advantages. By installing motors at each end and in the middle of the train, the driving power is distributed, which results in increased adhesion to the rails, greater power with reduced local weight, less pounding and vibration, and lighter rolling stock and track. Main lines, owing to their length and the large amount of power consumed, can scarcely be efficiently operated by direct current, except at prohibitive pressures; thus alternating currents must be looked to to solve the problem. Great experimental progress has been recently made in their adaptation to the needs of railway work, and there appears to be but little doubt that the near future will see the realisation of this form of electrical operation upon a large scale. Traction power house plant has of late years received much attention. Experience has proved that the strains set up in the engines and generators owing to the rapidly and sometimes largely varying load are not to be as much feared as was at one time thought to be the case. Good governing and considerable inertia are, however, essential in an engine destined for use on a traction circuit. Where direct current dynamos are used they are always compounded (*see* DYNAMOS), and special attention is paid to sparkless running in their design. A battery is an important adjunct in traction work, as it acts as a buffer, taking up a great deal of the load variation, and therefore saving the engines from abnormal strain. This is specially the case where an automatic reversible booster is used, that interesting piece of machinery having been designed to meet the special requirements of traction work in this direction.

F. H. D.

Electric Waves. When an electrical condenser is discharged by connecting its two coatings together through a conductor, a series of electrical oscillations is set up in the conductor. The plates or coatings become charged alternately with positive and negative electricity. The period of each oscillation is approximately $2\pi\sqrt{LC}$, where L is the coefficient of self induction of the circuit by which the two coatings of the condenser are connected, and C is the capacity of the condenser.

A succession of electrical disturbances or waves will start off from the system through the surrounding medium, having the same frequency as the oscillations in the conducting wire. These waves consist of electric and magnetic disturbances at right angles to each other and to the direction of propagation. The velocity of propagation is given by the equation $v = \frac{1}{\sqrt{K\mu}}$, where K is the SPECIFIC INDUCTIVE CAPACITY (*q.v.*) of the medium through which the waves are travelling, and μ is its MAGNETIC PERMEABILITY (*q.v.*) The waves may be conveniently produced by sparks from the secondary terminals of an induction coil, the conducting wires terminating in two polished spheres or cylinders placed at a small distance apart. To detect the presence of the waves various methods are used. One of the earliest consisted of a metal wire with a polished brass knob at each end, the whole wire bent round into a circular form so that the knobs nearly touch. The area of the circle so formed must be suitably adjusted to the particular wave lengths of the waves it is desired to detect; if this is done, the waves falling on the metallic circuit will produce small sparks which pass between the two knobs. The form of detector which is now most used is known as a COHERER. This consists essentially of loose contacts between pieces of metal. In BRANLY'S COHERER these are metal filings enclosed in a tube, through the ends of which wires are passed to serve as terminals; but many other forms of loose contact will give satisfactory results. A coherer of this type has a very high resistance, but when waves fall on it it becomes a good conductor. On tapping it very lightly after the waves have passed, it returns to its original condition, and ceases to conduct to any appreciable extent. If a coherer be connected in series with a cell and a galvanometer, a deflection of the galvanometer will occur when electric waves fall on the coherer, and will last until the coherer is tapped, when the current ceases, owing to the instant increase of the resistance of the coherer. Using these means for the production and detection of electric waves, many of their properties can be found by experiment. Thus it is found that they are capable of being reflected, refracted, polarised, and made to yield interference effects. Hence electric waves have properties resembling those of light; moreover, it is found that their velocity of propagation is the same as that of light, so far as can be ascertained from experiment. It is now believed, both as the result of theoretical investigations and of experiments, that light waves are simply electric waves of very short wave length and very high frequency; this is the main principle of Maxwell's ELECTROMAGNETIC THEORY OF LIGHT. Of recent years important applications of the properties of electric waves have been made by Lodge, Marconi, and others. *See* WIRELESS TELEGRAPHY.

Electric Welding. In many instances metals can be welded by heating the parts to be joined by electrical means. The process is used for pipes, rods, wires, sheet metal, tanks, barrels, special forms of chemical plant, large objects which cannot easily be moved, and other pieces of work which it would be difficult or even impossible to deal with in the forge. There are two methods, the INCANDESCENCE or THOMSON SYSTEM and the ARC SYSTEM. In the former a very large current with a low voltage (usually one or two volts) is passed across the junction from one piece of metal to the other; intense heat is produced in the immediate neighbourhood of the joint owing to the increase in the resistance of the hot metal. The two pieces of metal, on being pressed together, become welded into a homogeneous mass. Alternating currents are generally used; a small current, at a pressure or voltage of several hundred volts, is converted by a transformer, whose secondary coil may only consist of one single turn, into a large current of low voltage. As the transformer can be placed near the work, the necessity for long leads of sufficient size to carry the large secondary current is avoided; short heavy leads are brought from the secondary terminals of the transformer to clamps fixed on the work itself. The method is very convenient for the welding of large numbers of similar objects, which can be placed in succession in a suitable form of clamp or holder to which the terminals of the secondary circuit are permanently attached. The necessary operations may thus be reduced to a few very simple movements, and skilled labour may be largely or wholly dispensed with. In the Arc System a continuous current of much smaller amount, but with a voltage of 70 to 150 volts, is used, the current being controlled by suitable resistances. The positive terminal is attached to the metal and the negative terminal to a carbon rod, fixed in a holder which is held by the operator, or, in certain cases, is moved by mechanism. A powerful arc is formed between the metal and the carbon rod, and is caused to travel along the joint. By this method large pieces of work can be welded up *in situ*; but the operator requires a considerably higher degree of skill than is necessary in the case of the first method.

Electrification. The condition of a body which has received a charge of electricity. *See* ELECTRIC CHARGE *and* ELECTRICITY.

Electrochemical Equivalent. The mass (in grams) of a substance deposited by the passage of unit quantity of electricity (one coulomb). The electrochemical equivalent of hydrogen is ·000010352; that of any other element is obtained by multiplying this number by the chemical equivalent of the element in question.

Electrode. A conductor by which electricity enters or leaves any piece of apparatus; especially the two conductors (ANODE and CATHODE) by which a current enters and leaves an electrolyte.

Electrodynamometer. *See* DYNAMOMETERS, ELECTRICAL.

Electrolysis. *See* ELECTROLYTE.

Electrolyte (*Elect.*) A liquid with the property of conducting electricity by means of ELECTROLYSIS, or the splitting up of its molecules (or of the molecules of a substance dissolved in it) into separate atoms or groups of atoms, termed IONS. The ions themselves carry charges of electricity, and travel with a small but definite velocity through the liquid.

Electrolytic Dissociation. *See* DISSOCIATION.

Electromagnet. A core of iron or steel round which is wound a coil or SOLENOID of insulated wire, through which a current can be passed. The iron becomes magnetised during the passage of the current; when the current ceases, the magnetisation falls off to a very great extent, and may vanish almost entirely in the case of very soft iron.

Electromagnetic Theory of Light. *See* ELECTRIC WAVES.

Electrometallurgy. Metallurgical processes which are carried on either by the heat of the electric furnace (*q.v.*) or by the chemical action of an electric current. The preparation of pure copper by electrodeposition from a solution of impure copper salts is a good example of the latter method. Much of the copper employed for electrical purposes is now prepared in this manner. *See* COPPER.

Electrometer. A piece of apparatus for measuring differences of electrical potential. The simplest form is some modification of the electroscope (*q.v.*) provided with a scale for finding the angle of divergence of the gold leaves. The instrument has to be calibrated by the observation of the divergence produced by known differences of potential. The ATTRACTED DISC ELECTROMETER depends upon the mechanical force between two metal discs, which are charged up to the two potentials whose difference it is required to measure. If the distance between the plates is kept constant, the force with which they are attracted is proportional to the square of the difference of potential. If the distance between the discs is varied, the attracting force being kept constant, the difference of potential is simply proportional to the distance between the plates. The QUADRANT ELECTROMETER consists of a light paddle-shaped needle C, usually made of aluminium. This is suspended by means of a controlling fibre D, so that it can turn inside two pairs of hollow metal quadrants, AA, BB. In its position of rest it lies symmetrically between the two pairs, as shown. To measure a small difference of potential $V_1 - V_2$ (*e.g.* the difference of potential between the terminals of a single cell) the two quadrants AA are connected to one terminal of the cell and charged to the potential V_1; the pair BB are similarly connected to the other terminal, and charged to the potential V_2. The needle is maintained at a very high potential V_3 by connecting it to the inside coating of a small charged Leyden jar placed underneath the quadrants. Then, if the couple required to turn the needle through a given angle be proportional to this angle, the observed deflection will be proportional to $(V_1 - V_2)V_3$. Thus, if V_3 be kept constant, we can compare various values of $V_1 - V_2$, and the absolute value of this quantity can be found by observing the deflection produced by a Clark cell. To measure large differences of potential the needle is connected to one pair of quadrants; the couple exerted on the needle (and consequently the deflection) is then proportional to $(V_1 - V_2)^2$, where V_1 is the potential of one pair of quadrants, and V_2 is that of the needle and remaining pair of quadrants.

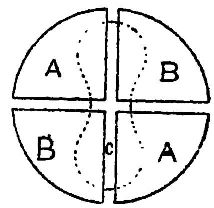


FIG. 1.—ELECTROMETER.

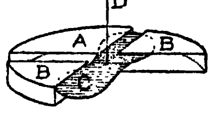


FIG. 2.—ELECTROMETER.

Electromobile. An electric automobile or motor car. *See* ELECTRIC AUTOMOBILE.

Electromotive Force *or* **E.M.F.** That which tends to cause the motion or flow of electricity. It is frequently termed ELECTRIC PRESSURE, or merely PRESSURE, by electrical engineers.

Electron. The name now generally used to denote the very small negatively charged "corpuscles" which constitute the cathode stream in high vacua, and which are also produced under other circumstances; *e.g.* they are emitted from negatively charged surfaces exposed to ultra-violet light, and also form the β rays emitted by radium. The negative charge carried by each electron is about $3{\cdot}4 \times 10^{-10}$ absolute electrostatic units, and appears to be a natural unit of quantity or a kind of "atom" of electricity. The mass of an electron is about $\frac{1}{700}$ to $\frac{1}{1000}$ of that of a hydrogen atom; but it is as yet uncertain whether this mass is real or of purely electrical origin, due to the fact that a charge in motion behaves as if it possessed inertia. *See also* ELECTRICITY.

Electrophorus. A flat plate of resin, or ebonite, laid on one conducting plate, and covered with another, which can be raised by an insulating handle. A small charge imparted to the resin (by rubbing) can be made to induce successive charges on the upper plate, which may be utilised in any way required. The source of energy is the separation (by the operator) of the plate and cover, which carry charges of opposite sign, causing an attractive force to be exerted between them. The work done in separating these charges appears as increased electrical energy on the upper plate, as its potential is raised by its withdrawal from the vicinity of the resin.

Electroplating. In general terms this consists of depositing the precious metals on the base metals (or on non-metallic substances which have been coated with a conductor) by means of electrolysis (*q.v.*) The articles to be electroplated form the cathode pole (*q.v.*) in a solution of the precious metal, the anode or + pole usually being a plate of the metal to be deposited. When a current of electricity is passed through the solution, a thin coating of metal is deposited on the articles forming the cathode, and the decomposed ions (*q.v.*) take up a fresh supply of metal from the anode. The individual methods of electroplating in general use are: (1) nickel plating, extensively used for making German silver goods and plating harness makers' ironmongery, buckles, etc.; (2) copper plating, generally employed for facing printing blocks, and coating non-metallic substances prior to gold, silver, or nickel plating; (3) silver plating, for cutlery and imitation silver ware; (4) gold plating, for ornamental work, and to a limited extent in the chemical industry, for lining the apparatus in which highly corrosive acids are rectified; (5) "Brassing" or conjoint deposition of zinc and copper in the proportions which constitute that alloy of these metals, called brass. Deposits of several other metals are obtainable, including aluminium, cadmium, antimony, bismuth, cobalt, iron, lead, and magnesium; and the principle of electro-deposition is employed for the separation of certain metals in the analysis of complex ores. The *process* of *plating* may be divided into two sections: the cleansing of the goods to be plated, and the preparation and management of the plating BATH, as the solution of the metal to be deposited is known technically. Cleansing consists in removing all grease, dirt, and scale, or oxide, by means of caustic alkali solution or acid pickle. The latter must not be used for lead, tin, or pewter. Iron is usually pickled in a solution of vitriol. For brass, DIPPING acid is often employed, being a mixture of nitric acid (aquafortis) and vitriol. In this way the goods are BRIGHTENED immediately before plating. In some cases it is necessary to prepare the goods by SOFTENING, which is really amalgamating slightly with

mercury; a cyanide scour is also employed sometimes, the object in all cases being to ensure the more perfect adhesion of the metallic deposit. For steel a muriatic acid pickle is usually employed. In the cleansing process, scratch-brushing is often used to produce a smooth surface, assisted by scouring with pumicestone. The quality of the plating largely depends on the way the surface is prepared, and cleansed, the articles being immersed in the bath immediately after cleansing and dipping. If a matt surface or dead lustre is desired, the goods, after cleansing and scratch-brushing, must be specially dipped, before plating, in a bath of aqua-fortis, vitriol, and a little white vitriol (zinc sulphate) and common salt. As this method is most applicable to copper or its alloys, other metals should be copper plated, and then prepared for a matt surface as just indicated. (6) The "bath" when made may be worked either hot or cold. Its composition depends on the articles to be plated, the current employed, and several minor factors which are determined by the individual working conditions. There are generally two brass rails round the top of the trough containing the plating bath, connected severally with the + and − poles of the battery or dynamo, and insulated from each other. By laying rods carrying the anodes on one rail and the cathodes on the other, the disposition of the articles in the bath (relative to the anodes, depth of immersion, etc.) can be adjusted so as to obtain the best deposit. *Nickel Plating* is one of the simplest and easiest managed methods of plating. There are about sixteen methods of preparing the "bath," which is usually worked hot; *i.e.* about 100° F. But in almost all cases the double sulphate (or chloride) of nickel and ammonium is the basis. Salt, sal-ammoniac, benzoic acid, etc., may be added, and are considered advantageous by various operators. Cast nickel plates are used for anodes, and care must be taken that by no chance shall the goods to be plated come in contact with the anodes. The current should be carefully regulated, as if too strong the deposit will be dull or "burnt," and if too weak, granular. The latter is a serious objection, as the nickel deposit will not stand the action of a burnisher, being of a brittle nature. For the same reason the surface must be carefully prepared before plating, to ensure the deposit being of the desired nature. *Copper Plating:* The bath is usually an acid solution of the sulphate or acetate of copper, containing also cyanide of potassium. For zincs and certain other articles an alkaline bath is used. Either hot or cold baths are used, the temperature for the former being 110° to 130° F. For iron, plain dipping without the passage of a current is sometimes adopted. The anodes are plates of copper presenting a surface at least equal to that of the goods to be plated. The hot bath is more rapid than the cold, and is specially suited for articles which are difficult to clean. Small articles should be kept agitated in a ladle or "trussed" on a wire. *Silver Plating:* The double cyanide of silver and potassium is used for the bath, prepared by dissolving nitrate of silver and cyanide of potash in water. Cold baths are mostly used for large articles and heavy deposits, and hot baths for small articles, and especially for tin, lead, zinc, iron, or steel goods, with a fairly strong current if constant agitation is adopted. For the best electroplate a preliminary amalgamating dip or else a "whitening" bath is almost always practised (*vide supra*). The bath improves, with working, and if portions of an old bath cannot be utilised in making up a fresh one, a bluish yellow deposit may be anticipated till the bath has aged a little. Silver foil or plate is used for the anode, which should have a greyish appearance when the current is passing. If black, there is not enough cyanide present; if white, there is too much, and silver cyanide must be added until a grey anode is obtained. Too strong a current produces a black deposit; a weak current yields a fine and dense deposit. A weak current and lengthened immersion produce a coating which burnishes far better than that from a strong current and quick plating. *Gold Plating:* A hot bath is customary at about 170° F., the cold method only being used for very large objects, such as chandeliers, but it needs much care and attention. The double cyanide of gold and potassium is used for all baths. The anode is generally platinum foil. Gold baths require considerable variation in composition for different metals. A universal bath is seldom a success. Excess of cyanide causes very slow plating, and the colour of the deposit ranges from green to red, according to the strength of the bath. This factor is also controlled by regulating the area of platinum anode exposed in the bath in a way which would be impossible with gold anodes. The greater the surface of platinum anode in the bath the redder the deposit. Gold plating is often applied only to selected portions of an article. To effect this a stopping-out varnish is used on the parts to be protected. *Brassing:* There are numerous methods of preparing baths, some eighteen recognised formulæ being practicable. Cyanides of zinc and copper, in conjunction with liquid ammonia or bisulphites, form the foundation of the majority, arsenious acid being used occasionally to brighten the coating, but only minute quantities are permissible, if deemed desirable. The chief difficulty is maintaining a deposit of uniform colour. A deficiency of current increases the copper, giving a red brass, and an excess brings up the zinc, resulting in a blue or pale brass. The amount of cyanide is also important. The anodes are brass plates, and all the articles must be kept at equal distances from them when plating. Hot baths are usual at about 135° F. (except for lead at 90° F.) Agitation is generally to be avoided. After all kinds of plating, the goods are rinsed in water, washed in boiling water (and in the case of brass goods in lime water), placed in sawdust, and sometimes stove dried. They are then burnished (if permissible) and buff polished. Anodes should always be removed from the bath when not plating, and the current should be started as soon as the articles are immersed, to avoid standing in the bath before plating. DIRECT COLD PLATING or FRICTION PLATING solutions have been introduced quite recently which contain *no cyanide* or other *poisonous* ingredient. They are essentially composed of very finely divided, precipitated chloride of silver, in the presence of excess of common salt, mixed with an abrasive, such as emery, rouge, or putty powder. By rubbing the solution on to copper, brass, bronze, etc., with a piece of clean flannel or cloth, a thin coating of pure silver is deposited. They do not lend themselves well to rough or ornamental surfaces.

Electroscope. An instrument for detecting small charges of electricity. The usual form consists of two pieces of gold leaf suspended from a conducting rod, so as to touch each other throughout their whole length when at rest. On connecting the conductor of the instrument to a charged body, the leaves become charged, and repel one another. A better form consists of a single narrow strip of gold leaf

which when at rest hangs vertically, in contact with an upright rod, to which it is attached at its upper end. The portion of the rod carrying the gold leaf or leaves is enclosed either in a glass case or in a wood or metal case provided with glass windows, through which the divergence of the leaves can be observed. The rod must be carried on a support which insulates it from contact with the case; the latter is connected to earth.

Electrotype Plates (*Print.*) A replica of type, woodcuts, etc., forming a printing surface. Produced by a galvanic deposit of copper which is afterwards backed up with an alloy.

Electrum (*Met.*) (1) An alloy of gold and silver, of the colour of amber, used by the ancient Greeks and Romans. (2) An alloy of copper, zinc, and nickel. (3) Native argentiferous gold, containing a large percentage of silver.

Element (*Chem.*) A substance which the chemist cannot, by any of the means under his control, resolve into two or more simpler substances. Among the best tests of the elementary nature of a substance are: (1) The effect of heat; the substance should not be decomposed. (2) The effect of an electric current; it should not undergo electrolysis. (3) Its spectrum; it should not contain a line or band exhibited by any other substance. (4) It should have, as a rule, a definite position in the periodic system. (5) Its behaviour on treatment with other substances, such, for example, as carbon, oxygen, chlorine, etc.

Elements (*Meteorol.*) The different items by which the total meteorological condition of the atmosphere is represented. These are: temperature, pressure, humidity, precipitation, evaporation, wind, cloud, electrical and optical conditions of the air.

Elements of an Orbit (*Astron.*) Quantities, seven in number, which describe an orbit of a planet accurately, and from which the planet's place can be found at any given time, past, present, or future, so far as the attraction of the sun alone is concerned.

Elemi (*Botany*). *Canarium commune* (order *Burseraceæ*). A resinous substance used in pharmacy. MANILA ELEMI is said to be the exudation from the stem of the above plant, while AMERICAN ELEMI is obtained from *Bursera gummifera.*

Elephant (*Print.*) A size of paper measuring 30 by 23 inches in printing, and 28 by 23 inches in writing and drawing papers.

Elers (*Pot.*) Elers ware was first made at Bradwell, Staffs, by John Philip Elers, about 1690. The ware is a red pottery of fine texture and careful execution. Elers was the first to introduce salt glazing into England. This is done by throwing salt into the fires when the kiln is at its hottest. The fumes given off combine chemically with the surface of the ware, causing a glaze to form upon it.

Elevation (*Eng., Build., etc.*) A view of an object as seen by an observer standing in front of the particular side represented. Thus FRONT ELEVATIONS are views of the front of a building; END ELEVATIONS are views of the end, etc.

Elevation Craters (*Geol.*) Most volcanoes occur within areas undergoing upheaval. The older geologists, noting this fact, were led to regard the conical form of volcanoes in general as having been due to local elevations caused by subterranean movements. Volcanic cones are now regarded as having been built up by the long-continued accumulation of lava streams and beds of tuff.

Elevators (*Eng.*) A series of buckets attached to an endless belt or chain for raising solids, etc., from one level to another up an inclined plane. The ascending buckets pass through a "boot" or hopper in which they scoop up a charge of material and discharge their contents as they begin to descend; *e.g.* dredger buckets.

Elgin Marbles (*Sculp.*) The most notable and valuable collection of ancient Grecian sculptures extant. They were brought from Greece by the seventh Earl of Elgin, and were purchased from him for the British Museum in 1816 These sculptures formed part of the adornments on the buildings of the Acropolis, Athens, and include many designs by Pheidias from the Parthenon or Temple of Athena.

PORTION OF THE FRIEZE OF THE PARTHENON.

The most important of these are the figures of Theseus or Hercules, Ilissus, and one of the horses of Night; fifteen Metopes in high relief, representing the battle of the Centaurs and Lapithæ; and a large portion of the exquisite frieze on the outer walls of the Cella, representing the procession to the Parthenon during the Panathenaic festival.

Elizabethan Architecture. *See* RENAISSANCE ARCHITECTURE.

Ellagic Acid (*Chem.*), $C_{14}H_8O_9$. A compound produced by the oxidation of gallic acid. It occurs in the oak bark, together with gallic acid and tannin; it separates out during the processes of tanning. *See* BLOOM.

Elland Stone. *See* BUILDING STONES.

Ellipse. A curve symmetrical about two axes at right angles, and such that if P be any point on the curve, and A, B, two points on the longer or MAJOR AXIS, which are termed the FOCI, then AP + BP is constant. The curve may be obtained by cutting right across a cone, at an angle with the base.

Ellipsoid. A solid whose three principal sections, taken at right angles to each other, are ellipses.

Elliptical Arch (*Build.*) An arch having the curve of a semi-ellipse.

Elliptic Comets (*Astron.*) The paths of comets are either elliptic, parabolic, or hyperbolic; there are about eighty-five (in 1902) which travel in elliptic orbits, and are called by the above name.

Elliptic Trammel. A device for drawing ellipses. A straight rod carries a pencil and two studs projecting at right angles to itself. The studs slide in two straight slots at right angles to one another. Each stud travels along one slot, *i.e.* in a straight line, and the pencil then describes an ellipse.

Elm. *See* WOODS.

Elongated (*Typog.*) A style of type of increased height in proportion to the normal width.

Elongation (*Astron.*) The difference between the celestial longitude (*q.v.*) of a body and the celestial longitude of the sun.

Elution (*Chem. Eng.*) A process for recovering sugar from molasses.

Elutriation (*Chem., etc.*) The separation of a lighter from a heavier powder by washing away the lighter one.

Elvan (*Geol.*) A name used by the Cornish miners, as well as by many geologists, for the dykes or wall-like masses of intrusive rocks allied in composition to granite, which rise through the older rocks of Cornwall and Devonshire, mostly in the neighbourhood of the large granite masses of those parts. Most elvans are, lithologically, quartz porphyries, but a few are more of the nature of porphyrites (*q.v.*)

Elzevir. The name applied to books printed by the Elzevier (Lat. *Elzevirius*) family at Amsterdam, The Hague, Leyden, Utrecht (1592—1680). The most valued are their editions of the classics, which are notable for their accuracy and for the elegance and neatness of the type.

Embankments (*Civil Eng.*) Masses of earth (obtained in excavation) raised above the level of the surrounding land: they serve to carry roads and railways, and as sea walls, river walls, etc.

Embattled (*Architect.*) Having battlements. One of the enriched mouldings used by the Normans is known as the embattled moulding, as it is carved to represent BATTLEMENTS (*q.v.*)

—— (*Her.*) One of the dividing lines of a shield, in form like the battlements of a castle. The angles are right angles.

Embedded Conductors (*Elect. Eng.*) Conductors on an armature of a dynamo or motor which run through grooves or channels in the iron core.

Embolite (*Min.*) Silver chlorobromide, Ag(ClBr); cubic; colour, asparagus green. It occurs in Chili in some quantity, also in Mexico and in Honduras.

Embossing. Ornament executed in relief, generally on a wrought surface. Applied also to carving or moulding done in relief.

—— (*Leather Manufac.*) Printing or embossing certain grain marks on skins by means of hot plates or rollers.

Embouchure. (1) The mouthpiece of wind instruments. (2) The position of the lip, etc., of performers on wind instruments.

Embowed *or* **Flected** (*Her.*) Curved or bent. It is employed for charges, as a fesse "embowed" instead of straight; or of some parts of the human body, such as the arm, and it is the position in which a fish is generally depicted.

Embrasure (*Architect.*) An opening in an embattled parapet. *See* BATTLEMENT.

Embroidery (*Lace Manufac., etc.*) Ornament on a fabric of any description, done either by hand with a needle, by the aid of a sewing machine, or by means of the embroidery machine. The foundation or fabric that is embroidered may be of such character as to be considered part of the scheme or design; or it may serve merely as a base until the work is completed, *e.g.* 'BURNT OUT' LACE (*q.v*). *See also* BAYEUX TAPESTRY.

Emerald (*Min.*) This well known bright green gem is a variety of beryl (*q.v.*) It is found in Siberia, Hindustan, Brazil, Norway, in the Andes, etc.

——, **Brazilian** (*Min.*) A green transparent variety of Tourmaline (*q.v.*)

Emerald Copper (*Min.*) A synonym for Dioptase (*q.v.*)

Emerald Green (*Dec.*) The brightest pigmentary green. Its hue is almost identical with spectrum green. *See* COLOURS (PIGMENTS, *etc.*) It contains a large proportion of arsenious oxide, and, being poisonous, its use has declined in recent years. It cannot be mixed with pigments containing sulphur, such as ultramarine, cadmium yellow, etc. In the United States it is called PARIS GREEN, and is largely used there as an insecticide.

Emerald Nickel (*Min.*) A hydrous carbonate of nickel, $NiCO_3 \cdot 6H_2O$. Oxide of nickel = 59·4, carbonic acid = 11·7, water = 28·9 per cent. Colour, emerald green. It occurs as an incrustation on decomposing nickel ores. Shetland, and Texas and Pennsylvania in the United States. Also called ZARATITE.

Emery. The rough massive varieties of CORUNDUM (*q.v.*); much used as an abrading agent. The emery of commerce often contains microscopic crystals of sapphire. Powder of varying degrees of fineness is obtained by crushing the mineral. It is used in the form of powder for grinding hard surfaces, or is formed into solid hones or into small wheels for sharpening tools of hard steel (such as twist drills, etc.) Found in Asia Minor, the Urals, and the United States. *See also* CARBORUNDUM.

Emery Buff (*Eng.*) *See* EMERY WHEEL.

Emery Paper and Cloth (*Eng., etc.*) Powdered emery attached to paper or cloth by glue; used for finishing metal surfaces.

Emery Wheel (*Eng.*) A wheel consisting of powdered emery made up into a solid mass with some kind of cement; used for grinding metal surfaces and sharpening tools. Wheels made of the finest emery are used for polishing; these are termed EMERY BUFFS.

Emission *or* **Corpuscular Theory of Light** (*Phys.*) An early theory that light was due to a great number of very minute particles or corpuscles projected or radiated from luminous bodies or sources of light. It is now superseded by the Wave Theory (*q.v.*), of which the Electromagnetic Theory is a development.

Emperor (*Print.*) A size of writing or drawing paper measuring 72 by 48 inches.

Empirical Formula (*Chem.*) *See* CHEMICAL FORMULÆ.

—— *or* **Rule.** A formula or rule which is based on the result of trial or experiment, not on theoretical calculations. A very large number of the rules used in various trades are of this nature.

Empress (*Build.*) A roofing slate measuring 26 by 16 inches.

Em Quads (*Typog.*) Quadrats or metal spaces used for filling out short lines, and cast 1 em (m) square to any particular body.

Em Rules (*Typog.*) Rules cast on an em (m) of any particular body, such as an em dash, —.

Emulsin (*Chem.*) An enzyme (*q.v.*) It occurs in almonds and probably in all plants which contain an enzyme capable of hydrolysing glucosides. It

can be obtained as a white powder by rubbing pressed almonds to a pulp with water, allowing to stand till acid fermentation sets in, filtering and precipitating with alcohol. It has the property of hydrolysing a large number of glucosides (*q.v.*); *e.g.* amygdalin, salicin, arbutin, etc., and it is remarkable that it hydrolyses milk sugar. *See* AMYGDALIN.

Emulsion (*Photo.*) A sensitive salt of silver held in suspension (in a very fine state of division) in collodion or gelatine.

Emys (*Zoology*). A genus of pond tortoises found in South Europe and in North America. They are eaten by the natives of the countries in which they live.

Enamel. The manufacture of enamel reaches back to prehistoric times, examples having been discovered in this country dating back to the Iron Age, while the Babylonians have left many specimens on their enamelled bricks. Enamels generally consist of a vitreous base, rendered more or less opaque by the addition of cryolite (*q.v.*) or fluorspar, colour being obtained as a rule by the addition of various metallic oxides. Enamels are usually applied either to pottery or metals; in both cases the enamel is caused to adhere by fusion. CHAMPLEVÉ ENAMELLING: The design is drawn on a copper plate, all the parts to be enamelled being excavated and the hollows filled in with enamels, which are fused and the surface then ground smooth. Limoges, in France, was for centuries the chief centre for this kind of enamelling. CLOISONNÉ ENAMELLING: The design is outlined by means of metal strips fixed on edge to the surface to be treated; the spaces between the strips are filled in with enamel, which is then fused and ground smooth, as in the preceding case. Examples of this kind of enamel are to be found in early Byzantine work. TRANSPARENT AND TRANSLUCENT ENAMELS were used by the Italian goldsmiths in the thirteenth century. ENAMEL PAINTING: This art, practised largely in the sixteenth century, is now rarely employed except for utilitarian purposes, such as names of streets, notices, advertisements, etc.

—— (*Cycle*). The "body" of the enamel is some resin, amber, or asphalt. This is dissolved in a solvent consisting of turpentine and boiled oil. Each coat is hardened by heating in an oven before the next is applied.

—— (*Dec.*) Paints drying with a highly glossy surface, made in a large variety of colours by mixing a pigment such as zinc oxide with copal varnish and other thinners (*q.v.*) The use of this class of paints has increased considerably of late years, both for inside and outside work. *See* ENAMELLING.

—— (*Glass Manufac.*) Coloured glass in which an excess of colouring agents are present, causing opacity.

—— (*Pot.*) Enamel colours are those containing soft fluxes that will melt and become affixed to the glazed ware in the enamel kiln (*q.v.*)

—— (*Zoology*). The substance forming the covering to the teeth. It is very hard, and has but little organic matter in its composition.

Enamel Kiln (*Pot.*) This differs in construction from the bisque and glost ovens, being of the MUFFLE form; that is to say, the flues encircle the inner lining of the kiln, and the heat is communicated to the ware by radiation, not by contact. It is used for firing painted and gilt wares. *See also* POTTERY AND PORCELAIN.

Enamelled Leather (*Leather Manufac.*) Known as PATENT LEATHER. The leather is coated with a varnish, and then heated. The varnish may be made any colour with metallic pigments. This gives the leather a coating similar to enamel.

Enamelling (*Dec.*) The process of painting wood and other work with an enamel giving a very glossy surface. In the best work at least six undercoats are given before the enamel is applied, and each is carefully rubbed down with fine sandpaper before the next is applied. In common work enamels are sometimes applied directly upon the ground, but this results in making the inequalities conspicuous.

—— (*Eng., etc.*) The coating of metal with some form of varnish, usually of a bituminous character. In many cases this is fused or STOVED by raising the whole piece of work to a high temperature.

—— (*Photo.*) The process of imparting a glossy and brilliant surface to a print by coating it with collodion or some other transparent medium, to which a smooth surface can be given; the term is sometimes applied to the mere burnishing of the film by steel rollers, etc.

Enantiomorphism (*Chem.*) Two crystals are said to be enantiomorphous when they are composed of the same crystallographic elements (faces, edges, angles), so arranged that the one is the mirror image of the other; that is, the one crystal cannot by any process of changing its position or by rotating it in any way be brought to congruence with the other. The right and left hands are enantiomorphous. Crystals of optically active substances are enantiomorphous, one crystal corresponding to the dextro compound and the other to the lævo compound.

Encastré (*Eng.*) A beam whose end or ends are built into a wall is said to be Encastré.

Encaustic. *See* PAINTING (METHODS).

Encaustic Painting. *See* PAINTING (METHODS).

Encaustic Tile (*Build.*) A coloured, baked, and glazed tile.

End (*Textile Manufac.*) A warp thread.

Endellionite (*Min.*) A synonym for BOURNONITE (*q.v.*)

Endemic (*Hygiene*). This term indicates a disease affecting a number of persons in a particular district, the cause being largely due to local circumstances. Of examples we have cholera in certain parts of India and smallpox in the Soudan.

End Grain. The surface of timber which is at right angles to the direction of the grain—*i.e.* a cut across the log or plank.

Endless Paper (*Print.*) Paper used in rotary machines, supplied in reels, as distinguished from paper in sheets.

Endless Rope *or* **Chain** (*Eng.*) A common expression for a chain or rope with its ends joined together; often used for transmitting power, as in a cycle or an overhead crane.

End Links (*Eng.*) Links of slightly greater strength than the ordinary links of a chain; added at the ends for welding up when the chain has to be connected to any other object. *See also* SHUTTING LINKS.

End Measurement (*Phys., Eng., etc.*) A measurement of length made by means of contact with the extreme end of the object. Callipers, screw gauges, and the Whitworth measuring machine all give end measurements.

Endocarp (*Botany*). The STONE or innermost layer of the pericarp of a drupe (*q.v.*) The shells of the walnut, cocoanut, and almond are the endocarps of drupes.

Endosperm (*Botany*). The tissue containing food substances (starch, proteid, oil, or cellulose) in certain seeds. *See* ALBUMEN.

Endothelium (*Zoology*). A form of squamous epithelium lining the body cavity and blood vessels.

Endothermic Compounds (*Chem.*) Compounds formed from their elements with absorption of heat. Most endothermic compounds cannot be formed *directly* from their elements; in such cases the heat of formation is obtained by calculation. Hydriodic acid, carbon disulphide, acetylene, the oxides of nitrogen (N_2O and NO) are examples of endothermic compounds.

End Papers (*Binding*). Usually known to the public as FLY LEAVES. The white or coloured sheets placed by the binder at the beginning and end of a volume, one half being pasted down upon the inside of the cover.

Endromis (*Archæol.*) A thick warm wrap, used principally by Greek and Roman athletes to prevent them from taking cold after exercise. There are frequent representations in classical art.

Energy (*Phys.*) The power or capacity for doing work. *See* KINETIC, POTENTIAL, RADIANT ENERGY, *etc.*

Engaged Column (*Architect.*) A column attached to a wall and projecting not less than half its diameter from the wall face.

Engine. (1) In the older uses of the word, any piece of mechanism. (2) A piece of mechanism used to convert heat or some other form of energy into mechanical work; in other words, a machine for the development of POWER (*q.v.*) from some source of energy, such as coal, gas, oil, compressed air, etc. *See* STEAM ENGINE, GAS ENGINE, *etc.*

Engine Cylinder, *etc.* (*Eng.*) *See* STEAM ENGINE, GAS ENGINE, *etc.*

Engine Friction (*Eng.*) The FRICTION (*q.v.*) between the moving parts of an engine; it is one of the chief causes of loss of power in the engine itself.

Engine Pit (*Eng.*) A depression or pit into which a man can get to examine the lower parts of a locomotive, motor car, etc., which is placed over the pit.

Engine Register (*Eng.*) A counting mechanism for showing the total number of revolutions made by an engine in any given time.

Engine Sized Papers (*Paper Manufac.*) Papers sized by the addition of resin, size, or other sizing materials, in the beating engine.

Englanté (*Her.*) *See* FRUCTED.

English Bond (*Build.*) A wall showing alternate courses of HEADERS and STRETCHERS (*q.v.*) on the face.

English Degrees. *See* DESCROIZILLES.

Engobe (*Pot.*) A term applied to a white paste or pipeclay found on ancient pottery.

Engrailed (*Her.*) A divisional line formed of semicircular indentations with the points from the figure. *See under* HERALDRY.

Engraving *and* Etching. The term engraving is necessarily comprehensive, since one may engrave upon almost any material—metal, wood, glass, shells, and even the soft plaster of the gable of a house, which latter process, called sgraffito, is really a kind of engraving. For the various methods of engraving upon metal plates, steel, copper, and zinc are most commonly used; the latter, however, only for coarse kinds of work, zinc being a very soft and porous metal. The processes employed in engraving and etching are intimately associated, and may be said to overlap each other, since most engravers make use of an etched line as a foundation for subsequent work with the burin, or graver, while on the other hand many etchers employ the burin as an adjunct or auxiliary to their etched work. The chief difference between the two processes is that while engraving implies the cutting or gouging of lines or spots by means of a sharp instrument, etching consists of biting or eating into the plate by means of acid or other chemicals. The result in each instance is essentially the same, a series of lines or other disturbance of the smooth surface of the plate, making an *intaglio* capable of holding printer's ink, from which a proof may be taken by pressure. LINE ENGRAVING: Line engraving does not appear to have been practised as a fine art before the beginning of the fifteenth century. It was largely employed for the illustration and embellishment of the earlier printed books, both in Germany and Italy, and afterwards as a means of reproducing pictures and other works of art. At the present time the art of pure line engraving is almost extinct, mainly owing to the length of time necessary to complete a plate, an important engraving on a steel plate not unusually occupying five years or even longer. The line produced is clean cut, even, and necessarily, from the method employed, somewhat severe, in this respect contrasting with the greater freedom of the etched line. *Printing of Line Engravings:* After being inked, the surface of the plate is wiped clean, the ink being left in the lines. The process employed in the printing of etchings, called "retroussage," is not employed. The impression struck off on paper is called an "Engraving." MEZZOTINT: This is a process by which the ground of the plate is entirely broken up by means of an instrument called the rocker or cradle. It raises a burr in such quantity as to give a rich full black in the proof. The plate is rocked from all possible angles—an extremely tedious process, forty different ways making a full ground. The ground is lowered for lighter tones by means of scrapers, the highest lights being polished with the burnisher. The ground is left untouched for the darkest shades. Pure mezzotints are produced entirely by means of the rocked ground and scraping. It is, however, a common practice to etch the outline of the subject first, and afterwards to have the ground rocked. The prints of Turner's famous "Liber Studiorum" were executed in this manner. Turner himself etched the outline or skeleton with a strongly bitten line, and trained engravers to carry out the mezzotinting. Mezzotint engraving was invented by Ludwig von Siegen, an officer in the service of William VI., Landgrave of Hesse-Cassel. Von Siegen communicated his secret to Prince Rupert, who introduced the art into England, and executed a number of plates, the most famous of which is "The Great Executioner," after Spagnoletto (1658). The golden period of mezzotint was between 1770 and 1800, when the principal paintings of Reynolds, Romney, Hoppner, and other artists were engraved in the most superb manner. These prints command a large price at the present time. STIPPLE ENGRAVING: This process is an

elaborate system of dots, no lines being used. The dots are arranged in such manner as to express the planes and modelling of the subject. In this process etching is employed as an adjunct or rather as a foundation for subsequent work with the burin, the dots being etched on a ground by means of an acid, and afterwards added to and deepened with the burin. The point of the stipple graver is bent *downwards*, this being the best shape for picking into the dots. For line engraving the burin is curved *upwards* at the point. Both bitten and cut lines are occasionally used in conjunction with the dots. Stipple engraving was introduced into this country by William Wynne Ryland (1738—1783). He acquired the art in France, where it had just been perfected by Jean François. Bartolozzi was one of the most successful practitioners of this method. Both mezzotint and stipple engravings were frequently printed in colours. WOOD ENGRAVING: The chief difference between metal and wood engraving lies in the fact that while in metal engraving the lines are represented by grooves cut in the metal, in wood engraving *the spaces between the lines are cut away*, leaving the lines in relief. This necessitates a very different method of printing, since in the case of metal the lines or grooves are filled in with printer's ink, and the surface of the plate wiped clean; whereas on wood it is the *surface only* of the block, represented by the lines in relief, which is inked. The tool employed is the graver, used in the same way as for metal. The earlier wood engravers made use of a small knife. Flat "scaupers" are used for clearing away spaces between the lines. The wood is usually box, although maple, plane, apple, pear, and beech are occasionally used for various kinds of work. The art of wood engraving originally came from the East, where it was practised by the Chinese from a very early period. Different forms of wood engraving have, however, been practised at most periods of the world's history, wood stamps being extensively employed by the Egyptians and Romans for the stamping of bricks and other materials; and wood blocks were also used, and are still used, for the stamping of printed fabrics—in fact, this is the process which William Morris employed at his works at Merton Abbey. Broadly speaking, the practice of wood-engraving as a fine art is coeval with the invention of printing, and from the earlier part of the fifteenth century onward most printed books were embellished with wood cuts, some of which attained a very high degree of excellence. Wood-engraving perhaps touched its high water mark in the hands of Dürer and Hans Burgkmair. From the beginning of the seventeenth century the art gradually declined; but the end of the eighteenth century was destined to witness a remarkable revival at the hands of Thomas Bewick, Blake, and others. Cheap modern "processes" have now almost completely superseded wood-engraving as a means of reproduction; but within the past few years there has been a distinct revival of this means of original expression, and an effort is being made to recall the best principles of the art. The late William Morris would have nothing whatever to do with "process," and all the illustrations of the famous Kelmscott Press were engraved, not indeed by the artists themselves (although Morris executed several blocks with his own hand), but by a capable artist who was perfectly in sympathy with the great traditions of the art. Original wood engraving is now being practised by a number of artists of distinction. In France it is the chief means of expression of one of the greatest of living craftsmen, M. Lepere.

ETCHING.

The meaning of the word etching is to eat or bite in, such biting being accomplished by means of some corrosive acid. A metal plate (usually copper) is covered with a "ground" formed of a thin coating of wax, capable of resisting the action of the acid. The subject is drawn upon the ground with a needle point, just sufficient pressure being used to remove the ground and lay bare the metal. The plate is then immersed in a bath of acid, which attacks only the lines drawn upon the plate. Lines of varying thickness are obtained by regulating the duration of the immersion. The fine lines are stopped out by means of a varnish applied to these lines, the stronger lines being obtained by again immersing the plate. The back and edges of the plate are also protected from the acid by means of such varnish. The printing of an etching requires considerable skill, very different results being obtained from the same plate in different hands. The plate is first heated, and the lines are filled in by means of a dabber, applied with a rocking motion to all parts of the surface, the superfluous ink being wiped off with muslin. The process called *retroussage* is then applied. This consists of passing soft muslin lightly all over the plate, especially in those parts requiring more *force*, gently dragging the ink over the edges of the lines, and thereby softening them. It is precisely this process which requires superior skill and judgment, and it is this process which constitutes the difference in the printing of an etching and a steel engraving. AQUATINT: This is a process by which the acid is allowed to attack large portions of the plate instead of lines. It is really etching by tones, and produces something of the effect of a wash drawing in Indian ink. The plate is only partially protected by a ground composed of asphaltum dust or resin dissolved in spirits of wine. The spirit evaporates, and leaves a thin even coating of dust or grain. The acid attacks the plate in the interstices, producing a flat tint. The variations of forms and tones are obtained by stopping out, as in etching. The tones may be further varied and modified by means of the burnisher. The etched line may be used in conjunction with aquatint, and in some aquatints an outline is first etched to give force and character to the work. SOFT GROUND ETCHING: In this process the ordinary etching ground is used, mixed with about half its weight of lard, more or less, according to the temperature of the air. The ground is laid with a dabber in the same way as an ordinary etching ground, and afterwards smoked with a taper. Thin paper is strained on the plate when cold. The drawing is made on the paper with a lead pencil. On removing the sheet, the paper takes up the varnish which adheres to it. The plate is then bitten in the usual way. The paper employed should have some grain, as a smooth paper gives no result whatever. The print which is obtained gives something of the appearance of a lead pencil or crayon drawing. DRY POINT: Theoretically this is the simplest of all forms of engraving, since nothing but a metal plate and a hard cutting point is needed. The actual practice, however, is far from simple. The design is drawn upon or cut into the bare metal with a point sharpened to a flat cutting edge. The point not only ploughs into the metal (copper usually), but raises a ridge or burr which catches the printer's ink and gives a soft, velvety effect in the proof. The amount of burr raised by the etching point depends

as much upon the angle at which the point is held as upon the amount of pressure exercised. A point held at an angle of, say, 45° will give more burr than that held perpendicularly with the same amount of pressure. Dry point plates will not yield a large number of prints, even when the plate is steel faced, as the burr wears away. Dry point is employed as an auxiliary to the bitten line, and elaborate etchings are generally finished with the dry point; but in this case the burr is removed by means of the scraper. SAND GRAIN: This process is used by some etchers with good results, but always as an auxiliary to the etched line. A ground is laid as for etching; a sheet of sandpaper is then laid face downwards on the plate, which is passed through the printer's press with sufficient pressure for the grains of sand to pierce the ground. The plate is then stopped out and bitten in the usual manner. Subjoined is a list of the more famous of the earlier engravers and etchers:

	Born.	Died.
ITALY.		
Andrea Mantegna	1431	1506
Botticelli	1437	1515
Marc-Antonio Raimondi	1480	1530
Parmigiano	1503	1540
Salvator Rosa	1614	1673
Canaletto	1697	1768
GERMANY.		
Martin Schongauer	1420	1499
Albrecht Dürer	1471	1526
Hans Holbein	1494	1543
Burgkmair (wood)	1473	1531
Altdorfer	1480	1538
Aldegrever or Aldegraf	1502	1558
HOLLAND.		
Rembrant	1607	1669
Adrian van Ostade	1610	1685
David Teniers	1610	1694
Paul Potter	1625	1654
Ruysdael	1625	1681
F. Bol	1611	1681
FLANDERS.		
Lucas van Leyden	1494	1553
H. Goltzius	1558	1617
SPAIN.		
Ribera (Spagnoletto)	1589	1656
Goya	1746	1828
FRANCE.		
Claude	1600	1682
Poussin	1597	1665
Joseph Vernet	1712	1789
Méryon	1821	1868
ENGLAND.		
Van Dyck	1599	1641
Hollar	1607	1677
Prince Rupert (introduced mezzotint into England)	1619	1682
Hogarth	1697	1764
Bartolozzi	1727	1813
Sir Robert Strange	1721	1792
Woollett	1735	1785

CHROMOXYLOGRAPHY.

Wood Block Engraving and Printing in Colour.

As in the case of wood engraving, this art came to us from the East. It is quite a recent art so far as Western nations are concerned, and up to the present the practice of it is almost entirely confined to this country. There is a general consensus of opinion amongst artists that the quality and texture of a chromolithograph, or indeed of any process of oil colour printing, is unpleasant and unsatisfactory compared with the beauty of surface and quality of a Japanese colour print. A few years ago experiments and inquiries were made by a little band of artists in London into the Japanese methods of engraving and printing in colour, with the result that a number of very successful prints have been produced, and classes have been formed for instruction in this branch of art at the Central School of Arts and Crafts in Regent Street and at other places. The Smithsonian Institute of Washington has issued a pamphlet giving details of the process, with photographs and drawings of the various tools and materials, and a certain amount of interest has therefore been aroused in the United States. The process is as follows: The wood employed is cherry or pear, cut *plankwise* instead of in transverse section, as in the case of box. The design is drawn upon thin tissue paper and pasted face downwards upon the wood. A careful cutting along both sides of the lines of the design is then made, a small knife being used instead of a burin or graver. The knife resembles a small chisel sharpened to an angle. The wood between the cut lines is then hollowed out with curved chisels, leaving the lines in relief, as in ordinary boxwood engraving. An impression of this is then taken upon Japan paper. This is called the key block, and is usually printed in Indian ink. Impressions from this key block are then pasted down upon fresh blocks, and the different colours of the design cut, necessarily in flat tints. A separate block or printing is necessary for each colour, although if a particular colour should occupy only a portion of the block, another colour may be cut upon the remaining portion of the same block. With care *both sides* of a plank may be utilised. It is necessary to have a system of register marks, in order that each print may fall in the right place during printing. *No mechanical means whatever are used in printing.* The colours employed are dry powder colours, mixed only with water and a little rice paste, and applied to the block by means of a large flat camelhair brush. Pressure is applied by means of a small flat pad or rubber made of some kind of soft leather, held in the hand and rubbed smartly backwards and forwards on the back of the paper, which is carefully placed upon the block. The paper, which is of a particular quality, made from the bark of the mulberry tree, is easily procurable in London, and should be placed between damped sheets of blotting paper before being used. The paper should, however, be first sized with gelatine size applied with a flat brush.—G. W. R.

Enharmonic Change (*Music*). The substitution of one or more notes for others practically the same; *e.g.* B for C♭, or A♭ for G♯.

Enharmonic Interval (*Music*). One less than a semitone. It cannot be obtained on keyed instruments, such as the pianoforte; *e.g.* C♯ and D♭ are the same note.

Enlargement (*Photo.*) A large print (or more rarely a negative) made from a smaller one by the use of an enlarging lantern. This is a form of optical lantern (*q.v.*) in which the small negative required to be enlarged is used in place of a slide, and the image is thrown on a sensitive surface, such as carbon or bromide printing paper. When a sufficient exposure has been given, the print is developed in the ordinary way.

Enol Form *or* **Enolic Form** (*Chem.*) Compounds which contain the group $- CO - CH_2 - CO -$ behave in certain reactions as if this group had the constitution $- C.OH = CH - CO -$; the latter is called the ENOL or ENOLIC FORM. Examples: ETHYL ACETOACETATE (*q.v.*), $CH_3CO . CH_2 . COOC_2H_5$, behaves in some reactions as if it had the formula $CH_3 . COH = CH . COOC_2H_5$. ACETONYL ACETONE (*q.v.*), $CH_3CO . CH_2 . CH_2COCH_3$, in some reactions behaves as if it had the formula $CH_3 . COH = CH . CH = C . OH . CH_3$. *See* TAUTOMERISM.

En Quads (*Typog.*) Spaces exactly half of an em, so that two en's (n's) equal one em (m).

Enrichment (*Architect. and Build.*) A general term for ornamental devices added to any structure or design.

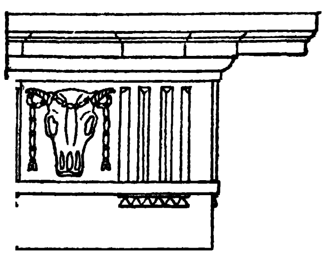
Enrichment of Coal Gas. *See* GAS MANUFACTURE.

Ensilage. A process of preserving green fodder for cattle by storing it in a SILO or pit, under pressure, without having previously dried it.

Ensor (*Lace Manufac.*) A very ingenious method of making net upon the Levers lace machine, invented by the late Mr. F. R. Ensor of Nottingham. It is double warp, and similar in appearance to Brussels net, but neither system of threads is traversed.

Enstatite (*Min.*) Magnesium silicate, $MgSiO_3$. Silica = 60, magnesia = 40 per cent. The variety BRONZITE contains up to 12 or 14 per cent. of iron. In various dull shades of green, grey, and brown. Rhombic; also massive and lamellated. It is one of the ortho-rhombic pyroxenes. *See* PYROXENE. From Northumberland and several parts of Scotland, Norway, France, etc.

Entablature (*Architect.*) The upper division of an order, above the columns, consisting of the cornice, frieze, and architrave. *See* COLUMN, ARCHITECTURE (ORDERS OF), CORNICE, FRIEZE, ARCHITRAVE, *and* BROKEN ENTABLATURE.



ENTABLATURE. ROMAN DORIC.

——. (*Eng.*) A plate or frame carrying some part of a machine (or other structure) which is fixed at some height above the baseplate and supported by struts or columns.

Entasis (*Architect.*) The swelling of a shaft beyond the form of a truncated cone. The delicate entasis used by the Greeks was just sufficient to prevent the shaft looking hollow, the curvature of the columns in the Parthenon being about ½ inch in 31 ft. In Roman work the entasis is obvious, instead of being hardly perceptible as in the case of the Greek columns. *See* ARCHITECTURE, ORDERS OF.

Ente (*Her.*) Various forms of dividing lines similar to indented lines, but curved instead of angular.

Entering Drill *or* **Tap** *or* **File** (*Eng.*) A drill, tap, or file, etc., which is used for the first approximate roughing out of a hole to its shape, but not for giving it its final form.

Entering, Passing, *or* **Drawing In** (*Silk Manufac.*) A process of drawing the warp thread by thread through the mail of mounture or eye of heddle. The various forms of entering are the "straight" pass, "skip" pass, "return" or "point" pass, "space" pass, "stage" pass, and "irregular" pass. STRAIGHT PASS: Entering the threads in regular succession through the eyes of the heddles. SKIP PASS: Entering through alternate heddles; *i.e.* if on eight shafts, taking the first, third, fifth, and seventh in succession, then the second, fourth, sixth, and eighth. RETURN OR POINT PASS: Entering in succession straight up the harness, and then straight down the harness. SPACE PASS: Entering several threads in succession on one shaft. STAGE PASS: Entering through more than one set of heddles for fabrics having mixed plain effects, such as Tabaret. IRREGULAR PASS: Any form of undefined entering to meet the requirements of certain fabrics. *See* HEDDLE, MAIL, MOUNTURE.

Entresol (*Architect.*) *See* MEZZANINE.

Entropy (*Heat*). That property of a body which remains constant when there is no communication of heat, but which increases when heat enters and diminishes when heat leaves the body.

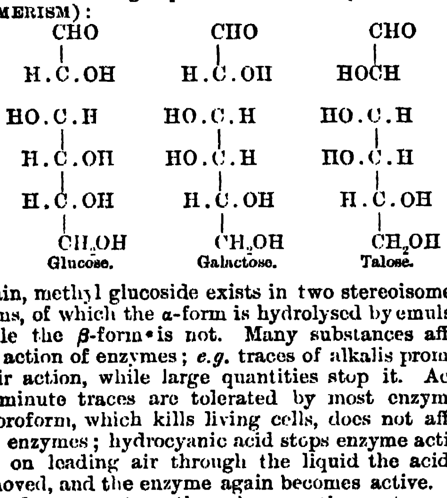
Entry, Right of (*Hygiene*). By the Act of 1891 the Sanitary Authority has the right to enter any premises for the purpose of examining as to the existence thereon of any nuisance liable to be dealt with summarily under the Act, at any hour by day, or in the case of a nuisance arising in respect of any business, then at any hour when that business is in progress or is usually carried on. The term "day" is defined as the period from 6 a.m. to 9 p.m. Practically the same power is given by the 1875 Act to officers of Local Authorities outside London. The main distinction is with reference to time of entry. In regard to private houses the officers shall be admitted at any time between the hours of 9 a.m. and 6 p.m., or in respect of any business, then at any hour when such business is in progress or is usually carried on. If entry is refused, a justice may grant a warrant upon application by the Sanitary Authority. Occupiers may require the person claiming the right to enter to produce some written document, properly authenticated on the part of the Sanitary Authority. The power of entry may be exercised by any members or officers of the Sanitary Authority, or persons authorised by them generally or in any particular case.

Envelope. (1) The bounding or covering surface of a solid. (2) A curved line (or surface) which is touched by every member of a series or family of curves.

Envelopes, Cometary (*Astron.*) Jets of incandescent material are thrown off from the nucleus of a comet as the sun is approached, and these jets form a series of concentric envelopes like hollow shells, one within the other, round the nucleus.

Enzymes *or* **Unorganised Ferments** (*Chem.*) Substances of entirely unknown constitution; they are probably related to the albumins—some (*e.g.* pepsin) more than others. Like albumins, they are precipitated from their solutions by alcohol and by certain salts, such as ammonium sulphate. They are colloids: as albumins are coagulated by heat, so, on boiling, enzymes lose their activity. They are produced in the living cells of plants and animals, and are obtained from these by various methods. *See* DIASTASE, EMULSIN, ZYMASE. They are very wide-

spread in nature, and are divided into classes according to the kind of action they produce; *e.g.* zymase hydrolyses monosaccharides; invertin hydrolyses disaccharides; diastase hydrolyses polysaccharides; and emulsin hydrolyses glucosides. Rennet coagulates albumin. Other enzymes, *e.g.* pepsin, convert albumin into the diffusible peptones; others bring about oxidation, and others reduction. All enzymes have the power of resolving hydrogen peroxide into water and oxygen. An enzyme has the property of acting upon a quantity of substance incomparably greater than its own mass; but its power in this direction is limited, and the action is never a complete one; *e.g.* emulsin cannot hydrolyse the whole of a given quantity of amygdalin at once; but if, when the action has stopped, ***the products of hydrolysis be removed***, the action will continue. This suggests that the change is a reversible one; and it has been shown in the case of the enzyme maltase that it not only resolves maltose into dextrose, but also changes dextrose to maltose. An enzyme of one class cannot effect the same change as an enzyme of another class; even slight differences in structure affect the activity of an enzyme; *e.g.* zymase ferments glucose readily, galactose with difficulty, and talose not at all. These stereoisomerides are represented by the following spacial formulæ (*see* STEREOISOMERISM):



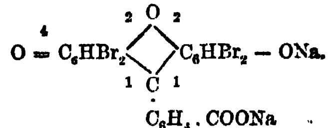
Glucose. Galactose. Talose.

Again, methyl glucoside exists in two stereoisomeric forms, of which the α-form is hydrolysed by emulsin, while the β-form is not. Many substances affect the action of enzymes; *e.g.* traces of alkalis promote their action, while large quantities stop it. Acids in minute traces are tolerated by most enzymes; chloroform, which kills living cells, does not affect the enzymes; hydrocyanic acid stops enzyme action, but on leading air through the liquid the acid is removed, and the enzyme again becomes active. As regards temperature, there is an optimum temperature at which the enzyme acts best. Enzyme action is catalytic, *i.e.* the enzyme itself remains unchanged after the action. Certain metals in a fine state of division acquire enzyme-like properties: such are platinum, iridium, gold, etc. To obtain the metals in this state the electric arc is made to pass under water between poles of the metal. In this way platinum gives a dark brown liquid in which the fine particles of metal are held in a state of suspension. This liquid decomposes hydrogen peroxide, traces of alkali promote its action, traces of acid do the same. It inverts cane sugar; it converts it at 150° into alcohol and carbon dioxide; it loses its enzyme-like properties on stronger heating; it is "poisoned" by hydrocyanic acid, and recovers its active properties on passing air through the solution. These metallic "solutions" have been named INORGANIC FERMENTS.

Eocene (*Geol.*) The lowest subdivision of the Tertiary Rocks. The name is based on the fact that marine fossiliferous rocks of this age contain a small percentage of molluscan species which are living in the same part of the Earth at the present day, and which may be regarded as ***marking the dawn*** (whence the name) of the present molluscan fauna. The British succession, stated from the top downwards, is as follows: Bracklesham Beds, Bagshot Sands, London Clay, Oldhaven Beds, Woolwich and Reading Beds, Thanet Sands.

Eolith (*Geol.*) A name applied to broken flints or other kinds of stone which are supposed to bear some distant resemblance to rude weapons shaped by human agency. The name was given because they were thought to be the earliest stone implements fashioned by primitive man, and therefore of older date than palæoliths.

Eosin (*Chem.*)



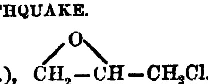
The sodium salt, or the corresponding potassium salt, of tetrabromfluorescein. Bluish red crystals; a dilute solution in water shows green fluorescence; a strong solution is bluish red. Acids precipitate the dye as a yellowish red solid. Used as a red dye for wool, silk, paper, biscuits. It is prepared by brominating fluorescein in alcoholic solution. The potassium salt of tetrabromofluorescein ($C_{20}H_6Br_4O_5 . K_2 + 6\ H_2O$) was one of the first substances employed in conjunction with ammonia for the preparation of orthochromatic plates sensitive to yellow green rays.

Eosine Colours. *See* DYES AND DYEING.

Epicalyx (*Botany*). An outer whorl of leafy structures in a flower, formed either by a series of bracts (*e.g. Mallow*) or by the fusion of the stipules of the sepals (*e.g. Strawberry*).

Epicentrum. *See* EARTHQUAKE.

Epichlorhydrin (*Chem.*),



A liquid smelling like chloroform; boils at 117°; insoluble in water. It is obtained from both dichlorhydrins (*see* GLYCERINE) by the action of caustic potash.

Epicyclic Gear (*Eng.*) Any gearing in which the centres of one or more of the wheels are not fixed to the frame of the machine, but describe circles. The DIFFERENTIAL GEAR (*q.v.*) used in motor cars is an example.

Epicyclic Train (*Eng.*) A set of EPICYCLIC GEAR (*q.v.*)

Epicycloid (*Eng., etc.*) The curve generated by any point in a circle which rolls round the outside of another circle. The teeth of ordinary gear wheels are formed of portions of epicycloids.

Epidemic (*Hygiene*). The term "epidemic" signifies a disease affecting a great number of people at a certain time. The disease may be distributed over a large area or confined to a particular community. It may recur in epidemic form from time to time, with intervening periods of complete immunity. *Cf.* ENDEMIC.

Epidermis (*Botany*). The external layer of cells in plants. The confluent outer walls form the cuticle, and this is, in some plants, greatly thickened.

Epidermis (*Zool.*) The outer portion of the skin or other covering of an animal, composed of one or more layers of cells. These layers are very numerous in the higher animals, and the outer layers give rise to hair, nails, etc.

Epidiorite (*Geol.*) A basic schistose rock, primarily of eruptive origin, which has undergone dynamic metamorphism, resulting in the conversion of the pyroxene it originally contained into one of the amphiboles. In many cases the parent rock was an intrusive sheet of dolerite. It is a common form of schist amongst the metamorphic rocks of the Scottish Highlands, as well as in those of other areas which have had a similar history.

Epidote (*Min.*) A basic calcium aluminium iron silicate, $H_2O . 4CaO . 3(Al . Fe)_2O_3 . 6SiO_2$. Monosymmetric. Colour, pistachio green to blackish green. It is an important rock-forming mineral, and occurs widely distributed. Some of the finest crystals are from Arendal, in Norway; also from the Western Islands of Scotland, the Urals, the Pyrenees, etc.

Epigraph. (1) An inscription. (2) A sentence or quotation at the commencement of the chapters of a book to indicate the sentiment or idea.

Epigyny (*Botany*). The condition in a flower when the thalamus, or flower axis, completely invests the ovary, leaving only the style and stigma exposed.

Epinaos (*Architect.*) The rear porch of a Greek temple. *See* CELL.

Epiphysis (*Zool.*) The end portions of a bone, separated from the shaft by a plate of cartilage in which are bone-making cells. By the addition of bone to the shaft and epiphysis, longitudinal growth is obtained.

Epiphyte (*Botany*). Plants which fix their habitation upon other plants without deriving food from them, as, for example, the orchids, certain species of which perch upon the branches of trees.

Epistyle (*Architect.*) *See* ARCHITRAVE.

Epithelium (*Zool.*) A tissue concerned chiefly in the process of SECRETION (*q.v.*) It consists of thin sheets of cells, and forms the epidermis, the lining of cœlom, alimentary canal, blood vessels, and the various ducts. There are two kinds—the SQUAMOUS or SCALY, and the COLUMNAR type.

Epsomite (*Min.*) Native Epsom salts; hydrous magnesium sulphate, $MgSO_4 . 7H_2O$. Rhombic; also in incrustations. Colourless or white. It is a common constituent of many natural mineral waters; it also occurs as an efflorescence on rocks which contain magnesium. From Epsom, Spain, Clausthal in the Harz, United States, etc.

Epsom Salts (*Chem.*) *See* MAGNESIUM COMPOUNDS *and* EPSOMITF.

Equation of Time (*Astron.*) *See* MEAN SOLAR DAY.

Equation, Personal (*Astron.*) Skilled observers note the passage of a star across a wire of a transit instrument, too late or too early, by an amount that is different for each observer, but nearly constant for each.

Equations (*Chem.*) *See* CHEMICAL EQUATIONS.

Equator, Celestial (*Astron.*) The great circle of the celestial sphere drawn halfway between the poles; it is that in which the plane of the earth's equator cuts the celestial sphere.

Equatorial (*Astron.*) A large telescope with an axis parallel to the axis of the celestial sphere, and rotating at the same rate by means of clockwork. A star once brought into the field of view then remains in the field as long as required. A second axis at right angles to the first enables the telescope to be adjusted to the correct altitude at the commencement of the observation.

Equatorial Radius of the Earth. *See* RADIUS OF THE EARTH.

Equator, Terrestrial. A great circle on the earth at right angles to the axis through the poles.

Equerre *or* **Escarre** (*Her.*) Used by French and German heralds for a charge resembling the "canton." Called also in ancient times "Angulus." A corner of a shield cut off by an elbow shaped band of another tincture.

Equilateral Arch (*Build.*) A pointed arch constructed on an equilateral triangle.

Equilibration (*Eng.*) BALANCING (*q.v.*)

Equilibrium (*Mech.*) The condition of two or more forces which, when acting together on a body, produce no motion.

——, **Neutral** (*Mech.*) The condition of a body when in equilibrium which is neither stable nor unstable. A sphere or cylinder resting on a horizontal plane is in neutral equilibrium.

Equilibrium Ring (*Eng.*) A ring of metal fitted to the back of a large slide valve, and making a smooth fit or contact with the back of the valve chest; or fixed to the inside of the valve chest, and making contact with the back of the valve. The space inside the ring is kept in communication with the exhaust, thereby diminishing the pressure on the valve and rendering it easier to move.

Equilibrium Slide Valve (*Eng.*) A slide valve in which the steam pressure is relieved by an EQUILIBRIUM RING or some other means.

Equilibrium, Stable (*Mech.*) A body is in stable equilibrium if, after receiving a small displacement, it returns (or tends to return) to its original position; *e.g.* a sphere resting inside a hollow sphere is in stable equilibrium.

——, **Unstable** (*Mech.*) A body is in unstable equilibrium if, after receiving a small displacement, the forces which act on it tend to increase its displacement. A sphere poised on the top of another sphere is in unstable equilibrium.

Equinoctial Points (*Astron.*) The points at which the ecliptic cuts the celestial equator. They are termed respectively the FIRST POINT OF ARIES and FIRST POINT OF LIBRA, though, owing to precession, they no longer lie in the constellations from which they take their names.

Equinoxes (*Astron.*) The dates when the sun crosses the equator; *i.e.* March 21st (the Vernal Equinox) and September 23rd (the Autumn Equinox). The day and night are then of equal duration.

Equipolle (*Her.*) A French charge resembling "Chequy," only the number of the squares is limited to nine. The centre and four corner squares differ from the four other squares in tincture.

Equipotential Surface (*Phys.*) A surface, either real or imaginary, every part of which is at the same potential (*q.v.*) The surface of a conducting body is always an equipotential surface so far as concerns electric forces.

Equisetum *or* **Horsetail** (*Botany*). A genus of fern plants growing in swampy places, and having jointed stems with whorls of slender branches. The stems of one species are used, under the name of DUTCH RUSHES, for polishing. Silica is abundant in the cell walls.

Equivalence (*Chem.*) Another term for VALENCY (*q.v.*)

Equivalent (*Chem.*) The equivalent of an element is that weight which will combine with, or displace from combination, one part by weight of hydrogen. The equivalent of an element is the same as the quotient (atomic weight ÷ valency). The equivalent of a non-metal can be found by analysis of its hydrogen compounds, that of a metal by finding the weight of hydrogen displaced by a known weight of the metal from an acid, or in case the metal is not acted upon by an acid in such a way as to set free hydrogen, by converting a known weight of the metal into an oxide, weighing the oxide, and calculating the equivalent from the fact that 8 parts by weight of oxygen are equivalent to 1 part by weight of hydrogen.

Equivalent Focal Length (*Photo.*) A term applied to a compound lens. The equivalent focal length of a compound lens is equal to the focal length of a single lens, which would produce the same magnification of a distant object as the compound lens under consideration.

Equivalent Lens (*Phys., etc.*) A lens is equivalent to a given combination of lenses if, when placed in the position of the one on which light first falls, it produces the same deviation in the axis of an eccentrical pencil as the combination does. The expression "equivalent lens" is at times also used to denote a single lens of the same focal length as a combination of lenses.

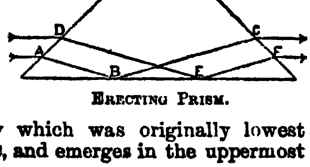
Equivalent Points of a Lens (*Light*). *See* PRINCIPAL POINTS.

Erased (*Her.*) When a charge is left with rough or jagged edges (three in number) as if violently torn off. If trees are shown thus the term is *eradicated*. It is the converse of COUPED.

Erbium (*Min.*) Does not occur native. It exists in combination in the following minerals:—Double salts: Fergusonite, Fluocerite, Euxenite, Polycrase, Yttrotantalite, Nohlite, and Cyrtolite. Fluoride: Yttrocerite. Niobate: Sipylite. Phosphates: Rhabdophanite, Scovillite. Silicate: Cenosite, Eucrasite.

Erechtheum. A famous Ionic temple dedicated to Athena Polias, the guardian of the city of Athens. It was situate on the Acropolis, to the north of the Parthenon, and was remarkable for its architectural variety, one of the most notable features being the Porch of Caryatids. Portions of the sculptures which decorated the structure now form part of the Elgin marbles in the British Museum.

Erecting Prism (*Light*). A glass prism, usually having one angle of 90° and two of 45°. If parallel rays be incident on one face at A and D, they are refracted to B and E, where they undergo total internal reflection, emerging at C and F. The ray which was originally lowest follows the path ABC, and emerges in the uppermost position; hence a beam from a lantern, which would otherwise produce an inverted image on the screen, can be caused to produce an erect image. This device is much used when an erect image is required of an object which cannot be placed in an inverted position in the lantern.



ERECTING PRISM.

Erecting Shop (*Eng.*) The department of an engineering works where the component parts of machines are put together. It usually contains no machine tools, but has a travelling crane for moving heavy work, and small hand tools used in the final fitting together of the separate parts of the work.

Erg (*Phys.*) The unit of work in the centimetre-gram-second system: the amount of work done when a force of 1 dyne is overcome through a distance of 1 centimetre.

Ergot (*Botany*). *Claviceps purpurea*, a fungus parasitic upon the grain of cereals, especially rye. The fungus absorbs the tissues of the ovary or young grain, and then forms a compact violet mass termed a SCLEROTIUM, or, in pharmacy, ERGOT.

Erica (*Botany*). The "heaths" form a genus of the *Ericaceæ*. *E. scoparia*, a native of the South of France, has a stout rootstock used for making "briar" wood (= BRUYÈRE WOOD) pipes.

Ericaceæ (*Botany*). An order of dicotyledons of widespread distribution. Their habit ranges from small woody plants to shrubs and trees. Well known genera are the HEATHS (*see* ERICA), ARBUTUS, and RHODODENDRON.

Eriodendron (*Botany*). The silk cotton tree (*E. anfractuosum*) belongs to the order *Bombacaceæ*: it is a native of tropical America. The silky hairs surrounding the seeds are used as stuffing for cushions.

Eriophorum (*Botany*). The cotton sedge, order, *Cyperaceæ* (*Monocotyledones*) has a perianth of bristles around the female flowers. These hairs are used as a stuffing for cushions, etc.

Ermine (*Her.*) (1) A tincture representing white fur with black spots. The spots take various conventional forms, typical of the black tail end of the ermine. (2) The animal itself.

—— (*Zool.*) The ermine (*Mustela erminea*; fam. *Mustelidæ*) is the stoat in its winter fur; the fur in summer is reddish brown. It is closely allied to the weasel. The white fur which forms the ermine of commerce is chiefly obtained from Alaska. The black tips of the tails of the animals are arranged on the skins at intervals for effect. Formerly portions of the tails of black lambs were used instead. The fur is used in this country more especially as trimming on the robes of judges and peers.

Ermines (*Her.*) A tincture representing fur similar to ermine, but reversed; *viz.* white spots on black fur.

Erminois (*Her.*) A variation of the fur, *i.e.* on a field "or," spots "sable." The reverse of erminois is called PEAN; *viz.* a field "sable" with spots "or."

Eros, Asteroid (*Astron.*) The name given to a minor planet discovered in 1898. It is the most important of this class of bodies, as it comes so close to the earth at times that it affords the most precise means of determining the solar parallax, from which the distance of the sun is deduced.

Erosion (*Geol.*) A term applied to any one of the natural processes by which rocks of any kind are wasted away. This includes chemical erosion, as well as the waste effected by prolonged exposure to the action of glaciers, rain, rivers, frost, blowing sand, the waves of the sea, etc.

Erratics (*Geol.*) A term now restricted to rock fragments of any dimensions, which have been transported from their native locality to another part by the action of moving ice. The term BOULDER is nearly or quite synonymous in geological terminology with the term Erratic.

Error of a Chronometer. The amount by which it is wrong when it indicates noon (0h. 0m. 0s.) If the clock is slow, the error is reckoned positive; if fast, negative.

Erubescite (*Min.*) A sulphide of iron and copper, $3Cu_2S_3 . Fe_2S_3$. Copper = 50 to 71, iron = 6·5 to 18, sulphur = 21·5 to 28 per cent. Cubic, more often massive; colour reddish; metallic, but when exposed it rapidly tarnishes. When in quantity it constitutes a valuable ore of copper. From Central and South America in quantity; also found in Cornwall, Tuscany, Germany, Norway, and the United States.

Eruptive Rocks (*Geol.*) Those rocks which have consolidated from a molten condition. They are usually classified as PLUTONIC, TRAPPEAN, and VOLCANIC ROCKS (*q.v.*)

Eryngium (*Botany*). Our native species grows on the sea shore, and is known as SEA HOLLY (order, *Umbelliferæ*). A tropical species yields valuable fibre. *See* CARAGUATA.

Erythrina (*Botany*). A small Indian tree (*Erythrina indica*; order, *Leguminosæ*) cultivated as a support for the pepper plant, and also as a shade for coffee shrubs. *E. umbrosa*, a taller tree, is used in South America to protect cocoa plantations.

Erythrine (*Min.*) A hydrous arseniate of cobalt, $Co_3As_2O_8 . 8H_2O$. Oxide of cobalt = 37·5, arsenic acid = 38·5, water = 24·0 per cent. Nickel may replace some of the cobalt. Monosymmetric; more often it occurs as a powdery incrustation of a crimson red colour. Cornwall, Alston Moor, Saxony, Bohemia, Norway, France, Missouri, etc.

Erythritol *or* **Erythrite** (*Chem.*) $CH_2OH . (CHOH)_2 . CH_2OH$. White solid, crystallising in prisms; is optically inactive; has a sweet taste; is very soluble in water; melts at 126°. Its behaviour is that of a tetrahydric alcohol. It occurs free in *Protococcus vulgaris*, and combined with orsellinic acid in many lichens and in some algæ. It may be obtained from lichens by saponification with milk of lime, out of contact with air. By cautious oxidation with dilute nitric acid it yields the aldehyde ERYTHROSE, $CH_2OH(CHOH)_2CHO$. Its nitrate is used in medicine in Bright's disease.

Erythrosin *or* **Iodeosin** (*Chem.*) Has the same formula as EOSIN (*q.v.*), except that the bromine of the latter is replaced by iodine. Soluble in water, giving red solutions, which do not fluoresce. It dyes wool and silk a bluish red colour. It may be obtained in a similar manner to eosin, using iodine in place of bromine. The free acid may be used in moist ether solution in titrating very dilute normal solutions (down to $\frac{1}{1000}n$) when all other indicators fail; it can also be used in titrating alkaloids. It is employed in orthochromatising gelatine plates; but since the shade of the dye is bluer, the position of maximum sensitising action lies nearer the D line in the spectrum. *See also* DYES AND DYEING.

Erythroxylum (*Botany*). Order, *Erythroxylaceæ*. A tropical American genus and order. The well known Coca tree is a member of this genus. *See* COCA.

Escallop (*Her.*) A single shell of a bivalve mollusc belonging to the pecten genus. Its serrated edge is its characteristic feature. Pilgrims brought these shells back with them from the shrine of St. James at Compostello; thus the escallop became the badge of a pilgrim or palmer.

Escapement (*Watches and Clocks*). That part of a watch or clock that checks the advance of the going train, and at intermittent intervals allows the energy of the motive power to "escape" to the balance or pendulum. *See* CHRONOMETER, CYLINDER, DEAD BEAT, DETENT, DUPLEX, GRAVITY, LEVER, PALLETS, RECOIL.

Escarpment (*Geol.*) The more or less steep outer edge formed by an inclined bed of rock which is of a more durable nature than the bed above it and that below. For example, the English Chalk, which is more durable, on the whole, than the overlying Tertiary strata or than the underlying Gault, forms an escarpment around the landward margin of the Weald, and also across England from Dorsetshire to Yorkshire. In like manner the more durable beds of the Jurassic Rocks form escarpments for a similar reason.

Escartelé (*Her.*) A dividing line which has a square notch in the centre ; rarely used in English heraldry.

Eschallot (*Botany*). A well known vegetable (*Allium ascalonicum*; order, *Liliaceæ*) introduced from Palestine.

Escutcheon (*Her.*) The shield upon which arms are depicted, and sometimes used in a wider sense to denote the whole coat-of-arms, crest, motto, supporters, etc.

Esker (*Geol.*) *See* GLACIAL ACTION.

Espagnolette (*Build.*) A fastening used with French casement windows or sash doors. It consists of an upright metal rod, which is fixed on the meeting style of one leaf of the casement; the rod on being turned by a handle operates two hooks, which form the terminations of the rod, causing them to catch in plates or staples fixed to receive them. There are many varieties of this type of fastener, some forms being reeded, and shooting into sockets at the top and bottom.

Esparto Grass (*Botany*). A North African grass (*Stipa tenacissima*; order, *Gramineæ*) used in the making of cordage, mats, baskets, and especially paper.

Espressivo (*Music*). Expressively.

Essential Oils. The more volatile oils, as distinguished from the less volatile or FIXED OILS. *See also* OILS.

Essonite (*Min.*) A synonym for CINNAMON STONE (*q.v.*)

Essorant (*Her.*) Describes the attitude of a bird with wings spread as if flying; also termed VOLENT or SOARING.

Establishment (*Typog.*) A term applied to workmen who are employed at a fixed weekly wage, and who are then said to be "stab hands."

Ester (*Chem.*) A compound of an alcohol with an acid; *e.g.* alcohol, C_2H_5OH, unites with acetic acid, CH_3COOH, with elimination of water, forming ethyl acetate, $CH_3COOC_2H_5$, which is also called acetic ethyl ester. A general method of preparing esters is to mix the alcohol and acid together, and act upon the mixture with a dehydrating agent such as sulphuric acid, or hydrochloric acid gas, or zinc chloride.

Estelé (*Her.*) A foreign term similar to decapitated or decollated, *i.e.* having the head cut off, and used chiefly of birds and animals.

Etærio (*Botany*). An aggregation of fruits (drupes, achenes, follicles) derived from a single flower, *e.g.* the mulberry and strawberry.

Etching. *See* ENGRAVING AND ETCHING.

—— (*Glass Manufac.*) Corrosion of the surface of glass by hydrofluoric acid. *See* GLASS MANUFACTURE.

Etesian Winds (*Met.*) Winds of Southern Europe caused by the indraught of the cooler air of the Mediterranean, to replace the heated air which rises from the hot sandy desert of the Sahara.

Ethane *or* **Dimethyl** (*Chem.*) $CH_3 . CH_3$. A colourless, odourless gas, nearly insoluble in water, considerably more soluble in alcohol; liquefied at 93° C. under ordinary atmospheric pressure. Obtained by any of the methods used for the preparation of paraffins (*q.v.*)

Ethene (*Chem.*) Another name for ETHYLENE (*q.v.*)

Ether (*Chem.*) (1) A general name for compounds of the type $R-O-R^1$, where R and R^1 are alkyl radicals which may be the same or different. (2) Sometimes used to designate ESTERS or ethereal salts; *e.g.* acetic ether, nitric ether, etc., are old names sometimes used for ethyl acetate, ethyl nitrate, etc. (3) ORDINARY ETHER is DIETHYL ETHER, $(C_2H_5)_2O$. A mobile liquid with characteristic smell; sp. gr. 0·736; boils at 35°; extremely inflammable, burning with bright flame. Its vapour forms an explosive mixture with air, and when inhaled produces unconsciousness; hence its use in surgical operations. It dissolves in 10 parts of water, and is a valuable solvent for organic substances, such as fats and oils. Its chief reactions are: With strong sulphuric acid it yields ethyl hydrogen sulphate; with hydriodic acid it yields ethyl iodide; with ozone it forms a peroxide. Ether is made by mixing alcohol and sulphuric acid, forming ethyl hydrogen sulphate, and heating the mixture to 140°. If now alcohol be added gradually, the formation of ether is continuous, $C_2H_5HSO_4 + C_2H_5OH = (C_2H_5)_2O + H_2SO_4$. The above is called Williamson's continuous etherification process. On the large scale, benzene sulphonic acid is now much used in place of sulphuric acid.

—— (*Phys.*) The invisible medium assumed to fill all space, by means of which heat, light, and electric waves are propagated. It is not possible to say whether this ether consists of matter in the chemical sense of the word, but it must possess density and elasticity.

Ethereal Salts (*Chem.*) The same as ESTERS (*q.v.*) So called because they may be regarded as ethers in which one alkyl group is replaced by an acid group.

Thus: $\begin{matrix} C_2H_5 \\ C_2H_5 \end{matrix} \Big> O$ Ether. $\begin{matrix} CH_3CO \\ C_2H_5 \end{matrix} \Big> O$ Ethyl Acetate.

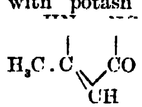
Ethine (*Chem.*) Another name for ACETYLENE (*q.v.*)

Ethoxides (*Chem.*) *See* ETHYLATES.

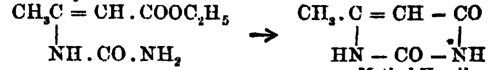
Ethyl (*Chem.*) The name given to the group C_2H_5. It only exists in combination.

Ethyl Acetate, Acetic Ether (*Chem.*) $CH_3COOC_2H_5$. A colourless fruity smelling liquid; boils at 77°. It is hydrolysed by water slowly, much more quickly by dilute alkalis and acids, $CH_3COOC_2H_5 + H_2O = CH_3COOH + C_2H_5OH$. Used to some extent as a flavouring agent. With sodium it gives sodium ethyl acetoacetate. With ammonia it forms acetamide. It is prepared by mixing alcohol and sulphuric acid, adding anhydrous sodium acetate, allowing to stand, and then distilling off the ethyl acetate; or in a similar manner from alcohol, acetic acid, and sulphuric acid; also by the action of acetyl chloride or acetic anhydride on alcohol, $CH_3COCl + C_2H_5OH = CH_3COOC_2H_5 + HCl$.

Ethyl Acetoacetate (*Chem.*) $CH_3CO . CH_2COOC_2H_5$. A pleasant smelling liquid, boils at 181°. It is one of the most important synthetic reagents in organic chemistry. It is prepared by acting upon ethyl acetate with sodium, distilling off excess of the former, acidifying with acetic acid, separating and fractionally distilling the liquid which floats on top after acidifying. It reacts in two ways: (1) as if it has the formula given above; (2) as if it has the formula $CH_3C . OH = CH . COOC_2H_5$. *See* TAUTOMERISM. Probably it is a mixture of much of the former with a little of the latter. Treated with sodium it yields sodium ethyl acetoacetate, $CH_3CO . CHNaCOOC_2H_5$, and this product with an alkyl iodide (RI) gives $CH_3CO . CHR . COOC_2H_5$. The latter with sodium and an alkyl iodide (RI) yields the compound $CH_3CO . CRR^1COOC_2H_5$. These alkyl substituted acetoacetic esters yield KETONES of the form $CH_3CO . CHRR^1$ when treated with dilute alcoholic potash, and ACIDS of the form $CHRR^1COOC_2H_5$ when treated with strong alcoholic potash; *e.g.* act upon ethyl acetoacetate with sodium and ethyl iodide, and obtain $CH_3CO . CHC_2H_5COOC_2H_5$; treat with strong potash and obtain Butyric acid, $C_2H_5 . CH_2 . COOH$. With phenylhydrazine ($H_2N . NHC_6H_5$) acetoacetic ester gives $\begin{matrix} CH_3C = CH . COOC_2H_5 \\ | \\ NH . NHC_6H_5 \end{matrix}$, and this compound ($\beta$-phenylhydrazidocrotonic acid) with potash yields 1:3 phenylmethylpyrazolone,



, a compound which yields ANTIPYRINE (*q.v.*) on treatment with methyl iodide. With urea we have a similar action to that of phenylhydrazine, and on treating the product with potash we obtain METHYL URACIL, a starting point for the synthesis of URIC ACID.



Methyl Uracil.

Ethyl Alcohol (*Chem.*) C_2H_5OH. *See* ALCOHOL.

Ethylamines (*Chem.*) When ethyl iodide is heated with alcoholic "ammonia" in sealed tubes the following substances are obtained: $NH_2C_2H_5 . HI$, ethylamine hydriodide; $NH(C_2H_5)_2HI$, diethylamine hydriodide; $N(C_2H_5)_3HI$, triethylamine hydriodide; $N(C_2H_5)_4I$, tetraethylammonium iodide; NH_4I, ammonium iodide. If this mixture is distilled with caustic potash, ammonia, ethylamine, $C_2H_5NH_2$, diethylamine, $(C_2H_5)_2NH$, and triethylamine, $(C_2H_5)_3N$,

pass over, and on leading them into a tube immersed in a freezing mixture, the ammonia alone escapes condensation. In the distilling flask the hydriodic acid has combined with the potash to form potassium iodide, and the tetraethylammonium iodide remains behind with the potassium iodide. The three amines which have distilled over are now acted upon with ethyloxalate, $\begin{array}{l}COOC_2H_5\\ |\\ COOC_2H_5\end{array}$, when the primary amine forms $\begin{array}{l}CONHC_2H_5\\ |\\ CONHC_2H_5\end{array}$, diethyloxamide, the secondary amine forms $\begin{array}{l}CON(C_2H_5)_2\\ |\\ COOC_2H_5\end{array}$, ethyl diethyloxamate, while the TRIETHYLAMINE remains unchanged, and may be distilled off. The diethyloxamide is a solid, and the ethyl diethyloxamate is a liquid, so that these may be separated by filtration. Each may now be distilled separately with caustic potash, giving respectively ETHYLAMINE and DIETHYLAMINE. ETHYLAMINE is a liquid which boils at 18°. Besides the above method of preparation, it is also obtained when methyl cyanide is reduced by hydrogen, also when nitroethane is reduced by hydrogen, and when propionamide is acted upon by bromine and caustic potash. With nitrous acid it yields ethyl alcohol. In other respects it resembles ammonia very closely indeed. *See also* DIETHYLAMINE *and* TRIETHYLAMINE.

Ethylates *or* **Ethoxides** (*Chem.*) Compounds produced by replacing the hydroxyl hydrogen in ethyl alcohol by metals; *e.g.* when sodium is thrown upon alcohol, we have the reaction $C_2H_5OH + Na = C_2H_5ONa + H$. C_2H_5ONa is sodium ethylate or sodium ethoxide. If the excess of alcohol be distilled off, it remains as a white crystalline solid, which is decomposed by water: $C_2H_5ONa + H_2O = NaOH + C_2H_5OH$.

Ethyl Benzoate (*Chem.*) $C_6H_5COOC_2H_5$. A colourless liquid with smell like pears; boils at 211°. Prepared by saturating a solution of benzoic acid in alcohol with dry hydrochloric acid gas, allowing to stand, and pouring into water, when the ester separates. May also be obtained by the BAUMANN-SCHOTTEN REACTION (*q.v.*)

Ethyl Bromide (*Chem.*) C_2H_5Br. A sweet smelling, colourless liquid; boils at 39°; insoluble in water. Obtained by dropping bromine upon amorphous phosphorus and alcohol, allowing to stand, and distilling. It is an important reagent in organic chemistry.

Ethyl Chloride (*Chem.*) C_2H_5Cl. A colourless, sweet smelling liquid; boils at 12°. Obtained by passing dry hydrochloric acid gas into alcohol containing zinc chloride, the latter serving to take up water; also obtained as a by-product in the manufacture of chloral. Used as a local anæsthetic, it freezes the part to which it is applied.

Ethylene Alcohol (*Chem.*) Another name for ETHYLENE GLYCOL (*q.v.*)

Ethylene Chlorhydrin (*Chem.*) *See* OLEFINES.

Ethylene Dibromide, Ethylene Bromide (*Chem.*)

$$\begin{array}{l}CH_2Br\\ |\\ CH_2Br\end{array}$$

A colourless, sweet smelling liquid, boiling at 131°. It is obtained by passing ethylene into bromine. Heated with alcoholic caustic potash, it yields, according to the amount of potash, VINYLBROMIDE or ACETYLENE.

$$\begin{array}{l}CH_2Br\\ |\\ CH_2Br\end{array} + KOH = \begin{array}{l}CH_2\\ \|\\ CHBr\end{array} + KBr + H_2O$$

$$\begin{array}{l}CH_2Br\\ |\\ CH_2Br\end{array} + 2KOH = \begin{array}{l}CH\\ |||\\ CH\end{array} + 2KBr + 2H_2O$$

See also GLYCOLS.

Ethylene Glycol (*Chem.*) *See* GLYCOLS.

Ethylene, Olefiant Gas (*Chem.*) C_2H_4. A colourless gas; faint sweetish smell; nearly insoluble in water; boils at −169° under ordinary atmospheric pressure. It burns with a bright flame, and with the proper proportion of oxygen (3 vols.) or of air (15 vols.) it forms an explosive mixture. Chlorine unites with it volume for volume, forming ETHYLENE CHLORIDE, $C_2H_4Cl_2$ (Dutch liquid). Bromine does the same; excess of chlorine in bright sunlight gives carbon and hydrochloric acid gas. For other reactions *see* OLEFINES. It occurs in coal gas (about 6 per cent.), being the principal illuminant in it. It may be obtained synthetically by reducing copper acetylide (*see* ACETYLENE) with zinc and ammonia, or in quantity by heating alcohol with sulphuric acid, or ethyl bromide with alcoholic caustic potash. *See* OLEFINES.

Ethylene Series (*Chem.*) *See* OLEFINES

Ethyl Ether (*Chem.*) *See* ETHER.

Ethyl Formate (*Chem.*) $H.COOC_2H_5$. A pleasant smelling, colourless liquid; boils at 54°. Obtained by heating glycerine, oxalic acid, and alcohol together in flask with reflux condenser; then the mixture is distilled. It occurs in rum, and is used in the preparation of artificial rum. It is easily hydrolysed. With zinc alkyls it gives SECONDARY ALCOHOLS.

Ethylidene (*Chem.*) A name given to the divalent group $CH_3.CH=$. Thus CH_3CHCl_2 is ethylidene chloride, a liquid obtained by the action of phosphorus pentachloride on aldehyde.

Ethyl Iodide (*Chem.*) C_2H_5I. A colourless, sweet smelling liquid; boils at 72°. Insoluble in water; turns brown on exposure to light, owing to liberation of iodine. Obtained by *gradually* adding iodine to amorphous phosphorus and alcohol, allowing to stand, and distilling. It is a very important reagent in organic chemistry.

Ethyl Nitrate (*Chem.*) $C_2H_5NO_3$. Colourless liquid; boils at 86°; it explodes when rapidly heated to a high temperature; burns with a bright white flame. Prepared by distilling a mixture of alcohol and nitric acid to which urea has been added to destroy nitrous acid. With tin and hydrochloric acid it yields hydroxylamine.

Ethyl Nitrite (*Chem.*) $C_2H_5NO_2$. A yellowish liquid, smelling of apples; boils at 16°; very inflammable. Prepared by the action of sulphuric acid upon potassium nitrite and alcohol. It is insoluble in water; a solution of the impure nitrite in alcohol constitutes SWEET SPIRITS OF NITRE.

Ethyl Oxalate (*Chem.*)

$$\begin{array}{l}COOC_2H_5\\ |\\ COOC_2H_5\end{array}$$

An aromatic smelling liquid; boils at 186°; does not mix with water. Prepared by heating *anhydrous* oxalic acid, alcohol, and sulphuric acid together in a

flask fitted with a reflux condenser; then pouring into water when the ester separates. With ammonia it gives a precipitate of oxamide. *See also* ETHYLAMINES.

Ethyl Red (*Photo.*) This dye has been strongly recommended by Dr. Miethe as a colour sensitiser for gelatine plates. The absorption spectra of its solution gives two maxima in the yellow green and green.

Etoile *or* **Estoile** (*Her.*) A star with generally six wavy rays. The mullet is also a star, but with five rays, generally plain, not wavy. An estoile may be also of "eight points"; then the rays alternate wavy and plain.

Etruscan Vases. *See under* VASES, POTTERY AND PORCELAIN, *and* GLASS MANUFACTURE.

Etui (*Cost., etc.*) A small case for holding needles, bodkins, toothpicks, etc. Cases of this kind, often of precious metal, chased, were much worn by ladies in the sixteenth and seventeenth centuries, hanging from the girdle. A case for pocket instruments.

Eucalyptus (*Botany*). Eucalyptus (a genus of the order *Myrtaceæ*). The oil of Eucalyptus is obtained by distillation of the leaves of *E. globulus* (blue gum), while the so-called red gum is an exudation from the bark of *E. rostrata*.

Euchlorine (*Chem.*) A name given by Davy to the mixture of chlorine and chlorine peroxide, obtained by the action of hydrochloric acid on potassium chlorate, under the impression that it was a single substance.

Eudiometer (*Chem.*) An instrument used to bring about the union of measured volumes of gases with the view of ascertaining the composition of one of them or of the product of their union. It is a straight glass tube, open at one end and closed at the other; near the closed end two platinum wires are fused into the glass, so that the sparks from an induction coil can be passed in the mixture of gases. It has a millimetre scale etched on the outside of it, and the instrument is calibrated before being used. To use it, the tube is filled with mercury and inverted in a vessel of mercury; the gases are then passed in, the volume being taken and corrected for difference of pressure after the introduction of each gas.

Eugenia (*Botany*). A genus of the *Myrtaceæ*, growing in the tropics. The fruits are valuable either as food or as spices. *See* CLOVES, ALLSPICE.

Eugenol, Eugenic Acid (*Chem.*) $C_6H_3\begin{cases} C_3H_5 & (1) \\ OCH_3 & (3) \\ OH & (4) \end{cases}$

An oil smelling like cloves; boils at 247°: it reddens litmus; gives blue colour with ferric chloride. It occurs in oil of cloves (85 per cent) and in oil of cinnamon. It is obtained from oil of cloves by shaking with alcoholic potash: this gives the potassium salt of eugenol; it is washed with alcohol and decomposed by an acid.

Euonymus (*Botany*). The dried bark of the root of the Wahoo tree (*Euonymus atropurpureus*; order, *Celastraceæ*) is the source of the drug Euonymin. *E. japonica* is one of our familiar evergreen shrubs. *E. europæus* is the common SPINDLE TREE.

Euphorbia (*Botany*). A genus of *Euphorbiaceæ*, of varied structure and habit. Many have a cactus-like form, but are distinguished by the presence of latex (*q.v.*) The acrid juice has many medicinal properties.

Euphorbiaceæ (*Botany*). A natural order of *Dicotyledons*, having a wide distribution and variety of habit. The presence of latex is common in the order. Many economic plants belong to the *Euphorbiaceæ*, such as CROTON, MANIHOT, HEVEA, CASTOR OIL (*q.v.*)

Eustachian Tube (*Zoology*). The passage leading from the pharynx to the tympanic cavity of the middle ear. Its function is to equalise pressure of air on either side of the tympanic membrane.

Eustyle (*Architect.*) The name given to the spacing of the columns in a Grecian temple when the space between the columns is equal to two and a half times the lower diameter of the shaft. *See* ARÆOSTYLE, PYCNOSTYLE, SYSTYLE, DIASTYLE, *and* INTERCOLUMNIATION.

Evaporation (*Phys.*) The process by which a liquid changes into a gas or vapour.

——, **Natural** (*Meteorol.*) Water exposed to the air evaporates at a rate which depends on the HYGROMETRIC STATE of the air (*q.v.*) When the air is nearly saturated, evaporation is slow; when the air is dry, it is rapid. In any given area the total amount of evaporation is almost always less than the rainfall.

Evaporators (*Chem. Eng.*) Any form of plant for removing moisture. Usually applied to plant used for concentrating liquids, as distinguished from plant for drying solids. Multiple evaporators are generally operated under a vacuum, and may be either single, double, or triple EFFECTS (*q.v.*) Vacuum evaporators are chiefly used in the sugar industry and the concentration of soap leys in the manufacture of glycerine. Their use is also spreading in the chemical trade for concentrating caustic solutions, etc.

Evaporimeter (*Met.*) An instrument for determining the amount of water evaporated in free air in a given time. Piche's instrument is simple and effective.

Evection, Lunar (*Astron.*) A term used with regard to the motion of the moon, and depending on the alternate increase and decrease of the eccentricity of the moon's orbit.

Evening Star (*Astron.*) A star setting near the sun, but just afterwards.

Even Pitch (*Eng.*) A screw in which the number of threads per inch is equal to that on the leading screw of the lathe on which it is cut, or is equal to that number multiplied by a whole number. In cutting a screw of even pitch, the right position of the tool for each fresh cut is readily found without turning the change wheels into any definite position.

Evolute. *See* INVOLUTE.

Excavation (*Eng.*) The digging out of earthy material (accomplished by hand labour or by mechanical means) and its removal to a suitable position. If the material is removed from under water, the operation is termed DREDGING.

Excavator (*Eng.*) A mechanical digging machine used in the construction of canals, railway cuttings, etc.

—— (*Civil Eng.*) Machinery for excavating; there are two main types, one consisting of an endless chain carrying iron or steel buckets which strike the ground in succession, removing a quantity of material each time; the other consisting of one

large scoop attached to a long lever: this type is usually termed a STEAM NAVVY.

Excentric (*Eng.*) A modified spelling of ECCENTRIC (*q.v.*)

Excitation (*Elect. Eng.*) The magnetising of the field magnets of a dynamo or motor by the passage of a current through the coils of wire on the limbs or cores of the field magnets. The current is either obtained from the machine itself in SELF-EXCITING DYNAMOS or is supplied from a separate source, in SEPARATELY EXCITED DYNAMOS. *See also* DYNAMO.

Exergue (*Coins*). The space on the reverse side of a coin or medal which lies below the principal device; it sometimes bears a *secondary inscription*, etc. On modern coins the date and engraver's initials generally occupy this position. The term is also applied to such *inscription*, date, etc.

Exhaust (*Chem. Manufac.*) The thorough extraction of a soluble body from insoluble ones by solvents, *e.g.* oil from seeds, sulphur from spent oxide, etc.

—— (*Eng.*) (1) The escape of steam or waste gases from an engine cylinder after expansion. (2) The waste gases themselves.

—— (*Phys. etc.*) The creation of a more or less perfect vacuum.

Exhaust Gases (*Eng.*) In a steam engine the exhaust gases consist of steam after it has expanded in the cylinder; it is cooler, at a lower pressure, and more charged with moisture, or "wetter" than on its entrance to the cylinder. In gas and oil engines the exhaust gases consist of the products of combustion, together with any unburnt gases remaining after the explosion.

Exhausting Fan (*Eng.*) A FAN (*q.v.*) used for pumping air out of any space or chamber.

Exhaust Lap (*Eng.*) *See* LAP *and* SLIDE VALVE.

Exhaust Line (*Eng.*) *See* INDICATOR DIAGRAM.

Exhaust Pipe (*Eng.*) The pipe which conveys the waste steam (or other gases) away from the cylinder.

Exhaust Port (*Eng.*) The opening which leads the waste gases from the cavity under the slide valve to the exhaust pipe. If the slide valve of an ordinary steam engine were removed, this port would be seen to lie between the two steam ports. *See also* STEAM ENGINE.

Exhaust Silencer (*Motor Car*). *See* SILENCER.

Exomis (*Archæol.*) A vest or short tunic without sleeves, worn by Greek and Roman artisans and slaves. It was fastened over the left shoulder, but passed under the right arm, leaving that arm and shoulder uncovered and free.

Exothermic Compound (*Chem.*) A compound in the formation of which from its elements heat is evolved. The majority of compounds are exothermic.

Expanding Bit (*Carp., etc.*) A boring bit capable of cutting holes of various sizes at will. There is a fixed central point which guides the tool, and a cutter carried on a radial arm, which can be set at a given distance from the axis of the bit. A very useful tool, especially when holes are required which differ a little from any standard size.

Expanding Metal (*Eng.*) Alloys of bismuth, which have the property of expanding on solidifying.

Expansion (*Eng.*) In general, any increase in the dimensions of a body; in particular, the increase in volume of the steam (or other gases) in an engine cylinder after the admission of steam has stopped, or after firing the charge in the case of a gas engine.

Expansion (*Phys.*) The increase in dimensions of a body; in particular, the increase in length, area, or volume produced in a body by raising its temperature. These three forms of expansion are termed LINEAR, SUPERFICIAL, and CUBICAL EXPANSION respectively. The coefficient of expansion is the increase per unit length, area, or volume of a body when heated 1°. If a, β, and γ represent the coefficients of linear, superficial, and cubical expansion respectively, l_o, a_o, v_o the length, area, and volume of a body at 0°, l_t, a_t, v_t the values of the same quantities at $t°$, then we have the following equations:

$$l_t = l_o\ (1 + at)$$
$$a_t = a_o\ (1 + \beta t)$$
$$v_t = v_o\ (1 + \gamma t).$$

Also it can be shown that

$$\beta = 2a$$
$$\gamma = 3a.$$

The values of a (within ordinary ranges of temperature) for some common substances are as follows:

Brass	·0000189
Copper	·0000166
Glass	·000009
Iron	·0000112

The coefficient of cubical expansion (γ) is ·00018 for mercury, and very approximately ·00366 for gases.

Expansion Curve *or* **Line** (*Eng.*) The part of an INDICATOR DIAGRAM which shows the relation of the pressure and volume of the steam, etc., in the cylinder during expansion. *See* INDICATOR DIAGRAM.

Expansion Engine (*Eng.*) Any engine using expansion in the cylinder. This may be taken to be universal in modern engines.

Expansion Gear (*Eng.*) The devices used to regulate the amount of expansion of steam in a cylinder; *e.g.* LINK MOTION, CORLISS GEAR (*q.v.*)

Expansion Joint (*Eng.*) A form of joint in pipes, etc., which allows a certain degree of movement, in consequence of longitudinal expansion, without breaking the joint. Various devices are used: a sliding socket joint, or a corrugated hoop, or pair of plates, or sometimes a simple bight or bend inserted between two straight lengths of pipe.

Expansion Rollers (*Eng.*) Rollers on which one end of a long girder rests in order to allow of the movement necessary during expansion and contraction, as the temperature changes, without disturbing the structure of which the girder forms a part.

Expansion Tank (*Eng.*) The cistern into which hot water pipes used for heating are fitted. It provides sufficient capacity to allow for the increase in volume of the water as the temperature rises.

Expansion Valve (*Eng.*) A valve which controls the CUT OFF (*q.v.*) of an engine; it is usually a separate slide valve, which stops the admission of steam to the main slide valve.

Expansive Working (*Eng.*) The use of EXPANSION in an engine; now practically universal.

Explosion. In general, the sudden combustion of any violently inflammable substance.

—— (*Eng.*) (1) The destruction of a boiler by the pressure of the steam becoming too high. (2) The FIRING of the CHARGE in a gas engine. *See* IGNITION.

Explosion Chamber (*Eng.*) The part of the cylinder of a gas engine in which the compressed charge is ignited.

Explosion Engines. *See* GAS ENGINES *and* PETROL ENGINES.

Explosion Wave. *See* EXPLOSIVES.

Explosives. Substances which can be made to undergo chemical change with great rapidity; the change is accompanied by the development of a large amount of heat, and the products of the change occupy a very much larger volume than that of the explosive itself. To learn something of the structural conditions of an explosive, consider ozone: it contains three oxygen atoms united thus, $\overset{O}{\underset{O-O}{\diagup\diagdown}}$; ordinary oxygen contains two oxygen atoms united thus, $O=O$. Ozone is unstable, being formed from oxygen, which is very stable, with absorption of heat. When ozone reverts to oxygen its heat of formation is set free, and we have an increase of volume, two volumes of ozone yielding three volumes of oxygen. But ozone under ordinary conditions is not an explosive; it is not possible to obtain gaseous ozone free from admixture with large volumes of oxygen, so that the change to oxygen is slow, the heat developed is feeble, and the change of volume small. With *liquid* ozone the case is different: it can be decomposed by shock, and the decomposition is rapid, the heat development considerable, and the change of volume from *liquid* ozone to *gaseous* oxygen is very great: it is an explosive. The union of nitrogen with oxygen is the basis of all practically applied explosives. The oxides of nitrogen $\left(\begin{matrix}N\\ |\\ N\end{matrix}\!>\!O,\ N-O,\ N\!\begin{matrix}\nearrow O\\ \searrow O\end{matrix}\right)$, though they are endothermic compounds (*q.v.*), are not explosives. But when this union of oxygen with nitrogen occurs in certain solid and liquid compounds, we have powerful explosives. NITRATES contain the group $-O-N\!\begin{matrix}\nearrow O\\ \searrow O\end{matrix}$ examples of explosives containing this group are gunpowder (*q.v.*), nitroglycerine (*q.v.*), and guncotton (*q.v.*), and combinations containing them, such as CORDITE. *See* DYNAMITE, BLASTING GELATINE. NITRO COMPOUNDS contain the group $-N\!\begin{matrix}\nearrow O\\ \searrow O\end{matrix}$: examples of explosives containing this group are the picric acid (*q.v.*) explosives (such as LYDDITE and MELINITE) and FULMINATING MERCURY. The power of these explosives is due to the facts (1) that on firing a large volume of gas is produced, (2) that strongly exothermic compounds are produced. Thus in the case of gunpowder, carbon dioxide and nitrogen are produced, and much heat is developed in the formation of potassium sulphide, carbon dioxide, and nitrogen. The reaction speed of a mechanical mixture such as gunpowder is not so great as that of a definite compound, such as nitroglycerine, guncotton, or picric acid; hence its disruptive effects are not so great—it is rather suited for the propulsion of projectiles. On firing an explosive such as mercury fulminate, the sudden pressure developed gives rise to what is known as an EXPLOSION WAVE, which in this case is propagated at a speed of about 1,600 mètres per second. This explosion wave propagated in the neighbourhood of endothermic compounds such as acetylene or cyanogen is sufficient to explode them.

Exposure (*Photo.*) The act of exposing or allowing the light to act upon a sensitive plate, etc.; also the time during which the light is allowed to act.

External Characteristic (*Elect. Eng.*) The curve showing the relation of the current flowing through the external circuit to which a dynamo is connected, and the potential difference between the terminals. *See* DYNAMO.

External Firing (*Eng.*) Heating a boiler by a firebox entirely outside the boiler itself, instead of in a flue or an internal firebox. The method is confined to early types, and is now rarely used.

External Screw *or* **Thread** (*Eng.*) An ordinary screw cut on a cylindrical surface. Also termed a MALE SCREW or MALE THREAD.

Extincteur (*Chem.*) An instrument used to extinguish small fires. It consists of a metal case containing carbon dioxide under pressure, generated in the vessel itself by the action of dilute sulphuric acid on sodium carbonate, and it allows of a jet of the gas being directed upon the fire.

Extraction of Oils. A method of obtaining oils by means of highly volatile solvents, such as benzene, carbon bisulphide, benzol, sulphuric ether, etc., which rapidly dissolve the fats contained in the seed meal and are afterward driven off completely by distillation, leaving the oil intact. The solvent is almost wholly recovered for further use.

Extractors (*Chem. Eng.*) Apparatus for the extraction of fats, oils, etc., by solvents (such as benzol carbon bisulphide, etc.), which are recovered by distillation and condensation.

Extrados (*Build.*) The upper curved side of an arch. *See* ARCH.

Extraordinary Ray (*Light*). *See* DOUBLE REFRACTION.

Extras (*Typog.*) Charges involved in composition in addition to the fixed price per page of text, such as for setting in foreign languages, tabular work, headings, etc.

Extra Weft (*Woollen Manufac.*) A special colour of weft yarn applied to the fabric, distinct from the ordinary or ground weft.

Eye (*Eng.*) A loop at the end of a rod or bolt.

—— (*Joinery, etc.*) The centre of a scroll.

—— (*Mining*). The top of a shaft.

Eye of a Furnace (*Glass Manufac.*) The recess containing fuel in the middle of the bed of a furnace, at the bottom of which are placed the fire bars or grating.

—— (*Met.*) The bright red spot in the hearth of a blast furnace seen through the nose of a tuyère by means of the mica-faced sight hole placed on the angle of the elbow connecting the blast main with the tuyère.

Eyepiece (*Phys., etc.*) Portion of the eye end of a telescope, microscope, etc. Sometimes known as an "Ocular."

Eyepiece Micrometer. *See* MICROMETER EYEPIECE.

F (*Chem.*) The symbol for FLUORINE (*q.v.*)

—— (*Music*). The fourth note of the scale of C.

f. (*Music*). Abbreviation for "forte": loud.

Fa (*Music*). The sol-fa syllable for F.

Fabrikona (*Dec.*) *See* CANVAS WALL COVERINGS.

Façade (*Architect.*) An external face of a building; generally used to denote the principal external face.

Face (*Eng.*) The principal or most important surface of an object, *e.g.* the graduated surface of a dial.

—— (*Min.*) An individual plane of a crystallographic form. *See also* SYSTEMS OF CRYSTALS.

Face Chuck (*Eng.*) A flat disc shaped chuck furnished with bolt holes and slots. Work can be fixed to the chuck by means of bolts passed through these holes.

Face Lathe (*Eng.*) A lathe which can take in a piece of work of very large diameter, but not of great length: used for turning large discs, wheels, armatures or field magnets of dynamos, etc.

Face Plate (*Eng.*) *See* FACE CHUCK.

Face Plate Coupling (*Eng.*) A COUPLING (*q.v.*) consisting of two castings with flat flanges, by means of which two shafts can be connected by bolts.

Face Side (*Join.*) The first surface of a piece of wood which is trued up. A mark is put on to distinguish it from the other sides.

Facet. (1) One of the faces of a gem where it has been cut and polished by a lapidary. (2) One of the faces of a natural or artificial body that has a series of such faces.

Facing (*Eng.*) A raised surface or projection on a casting, to which some additional part is to be fitted. This raised surface is much more easily machined, filed, etc., than a portion of the main general surface would be, and hence adds to the convenience of manufacture.

Facing Bar *or* **Work Bar** (*Lace Manufac.*) A smooth iron plate about 4 in. wide and the full width of the lace machine, over which the web of lace travels on its way to the roller.

Facing Paviors (*Build.*) Hard burnt malms of good colour and shape. Used for superior walls. *See* BRICKS.

Facings (*Build.*) (1) The best bricks, picked for the face of the work. (2) The stone dressings to door and window openings.

Facing Sand (*Foundry*). Sand mixed with coal or charcoal dust, used for covering the surfaces of a mould which are exposed to the molten metal. A thick coat of this sand prevents the formation of a skin of silicious matter on the casting.

Factor of Safety (*Eng., etc.*) In any structure the load which would break it down is several times as great as the safe load; the ratio of the Breaking Load to the Working Load is termed the FACTOR OF SAFETY.

Faculæ (*Astron.*) Bright portions on the solar disc which can generally be seen in the region of the spots, especially when near the limb of the sun.

Faenza Ware (*Pot.*) A distinctive term given to a fine sort of pottery originally made at Faenza near Bologna, in Italy. The majolica produced there was very beautiful; the plates (called "tondini") have wide rims and deep centres, and are adorned with arabesques and biblical and classical scenes.

Fagot (*Met.*) A bundle of bars of wrought iron which are welded up into a solid mass; this is afterwards hammered and rolled out into a new bar. By this means the fibre, or grain of the iron can be arranged to run in any required direction, and greatly increased strength is obtainable.

Fagoting (*Met.*) The process of welding up a FAGOT (*q.v.*)

Fah (*Music*). Fourth degree of scale in "Movable Doh" system.

Fahlerz (*Min.*) A synonym for TETRAHEDRITE (*q.v.*)

Fahrenheit's Scale (*Heat*). The scale in which the freezing point of pure water is marked 32°, and the boiling point 212°. The zero—32° below the Freezing Point—was based on an imperfect experiment, making the scale very inconvenient. It is now superseded for scientific purposes by the Centigrade Scale.

Faïence, Faience, Fayence, *or* **Fayance** (*Pot.*) The old French term, under which were comprised all descriptions of glazed earthenware, inclusive of porcelain, and to a certain extent this continues so, corresponding in its general use to the English word "crockery" (*Marryat*). Any pottery not transparent is generally termed "Faience." *See also* MAJOLICA.

Falchion (*Arms*). A short broad sword, curved, and with the outer edge sharpened: used in the Middle Ages. Later, the name has been applied to a sword of any kind. Used as a charge in Heraldry.

Faldstool. An armless folding chair sometimes used by bishops. It resembles a camp stool, but is more elaborate. A movable folding-desk: a Litany stool.

Fall (*Build.*) The inclination of a drain, gutter, etc.

—— (*Eng.*) (1) The slope given to a channel intended to carry water. (2) The quantity of water passing over a weir, mill race, etc.

—— (*Mining*). Material accidentally dislodged from the roof or sides of a working.

Falling Mould (*Joinery*). In hand-railing, the development in elevation of the centre line of the rail.

Fall Tube (*Air Pump*). *See* AIR PUMP.

False (*Her.*) Another term for VOIDED—*i.e.* with centre open.

False Bedding (*Geol.*) An inclined arrangement of the layers constituting rocks of sedimentary or of Eolian origin, which has resulted from their being deposited by currents which have varied much in their transporting power from time to time. The most striking and typical examples are those produced by the drifting action of the wind upon sand in desert regions or under similar conditions; but changeable currents of water often give rise to similar phenomena. The direction of slope of the false bedding planes coincides with the direction of movement of the transporting agent.

False Bottom (*Eng., etc.*) A removable bottom placed over the real or fixed bottom of a vessel in order to facilitate cleaning or other operations, or to economise the firing in a grate.

—— (*Chem. Eng.*) Usually a perforated plate which supports the contents of a boiler or kettle, in order to leave a space at the bottom of the vessel in which condensation products, drainings, etc., may collect, out of contact with the contents. It also

prevents the choking of draw-off cocks by the solids under treatment.

False Core (*Moulding*). A movable part of a mould or core, similar to a drawback (*q.v.*), which can be taken out in order to facilitate the lifting of the pattern.

False Key (*Eng.*) A KEY (*q.v.*) formed by a round pin driven into a hole drilled parallel to the axis of a shaft, half of it being in the shaft and half in the hub or boss of the wheel which has to be keyed on. It is much inferior to a key of the usual rectangular section.

False Relation (*Music*). The disagreeable effect produced by the close proximity of two chords having no relationship and belonging to different keys, but having a note in the first chord chromatically altered in the second and sounded in a different part.

Fan (*Cost.*) A small well known instrument for moving the air. The use of the fan was common amongst Eastern nations as far back as history reaches. In early times the fan used out of doors served the purpose of a parasol, and screened the face. Folding fans as now generally used were introduced in the seventeenth century.

—— (*Eng.*) Consists essentially of a set of radial blades rotating at a high speed, and enclosed in a case which is provided with suitable openings for the entrance and exit of air. In fans for producing a blast (used for furnaces and forges) the plane of the blades is parallel to the axis of the fan, but in fans used for exhausting or for ventilating a room by sucking or pumping air out, the plane of the blades is usually inclined to the axis in a similar manner to the blades of a screw propeller. In the latter case the flow of air is parallel to the axis of the fan: in the former it is at right angles to the axis.

—— (*Her.*) A winnowing basket: notable example on the Setvans or Septvans brass.

Fan Cooling (*Motor Cars*). A small fan, worked by the motor, is sometimes used to drive a current of cool air on to the outside of the cylinder to keep it cool, or to draw air through the condenser or radiator for the purpose of cooling the water which circulates round the cylinder and through the radiator.

Fan Curb (*Chem. Eng.*) *See* CURB.

Fancy (*Woollen Manufac.*) A roller in the carding machine, also termed "fly," for brushing up the wool on to the surface of the clothing of the main cylinder.

Fang (*Build.*) The portion of iron railings built into the wall.

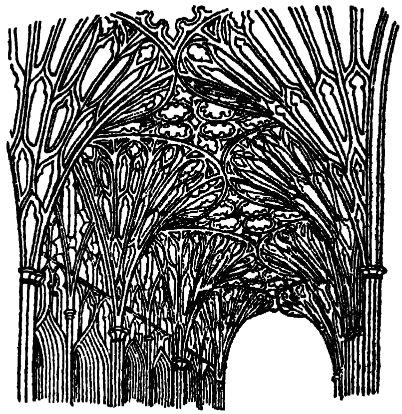
—— (*Mining*). A passage for conducting air along a working.

Fang Bolt (*Eng., etc.*) A bolt with pointed teeth formed on the nut. These teeth sink into wood through which the bolt passes, and prevent its rotating. The bolt itself is turned (like an ordinary wood screw) in order to screw it up.

Fanlight (*Joinery*). (1) The sash above a door. (2) The lights above the transom of a solid frame.

Fan Structure (*Geol.*) A term now restricted to such arrangements of highly disturbed strata as may be likened to the relative position of the leaves in a half opened book lying on its back, or to a pack of cards which is gripped by one edge and opened out at the other. Fan structure is rarely met with except within the cores of what are (1) now, or (2) formerly were, the inner parts of great mountain ranges, such as (1) the Alps of Switzerland, (2) the Southern Uplands of Scotland.

Fan Vaulting (*Architect.*) A species of vaulting peculiar to the Perpendicular style of English gothic architecture. The earlier gothic vaults consisted of constructional ribs supporting a thin filling, but in fan vaulting a return was made to the Roman method of vault construction, as the whole vault was often formed of jointed masonry on which the ribs were carved. Fan vaulting consists of a series of inverted



FAN VAULTING. GLOUCESTER CATHEDRAL, CIRCA 1450.

concave conoids, the semicircular summits of which are separated either by pendants or lozenge-shaped panels acting as keystones. The whole was covered with an elaborate system of panelling. Fine examples can be seen in Henry VII.'s Chapel, Westminster Abbey, and in the cloisters of Gloucester Cathedral. *See* BARREL VAULT, GROINED VAULT, RIB AND PANEL VAULT, *and* SEXPARTITE VAULT.

Farad (*Elect.*) The electromagnetic unit of capacity. A condenser has a capacity of 1 farad if its potential is raised 1 volt by 1 coulomb of electricity. Such a condenser would be of enormous size. The practical unit adopted is the one-millionth part of a farad, and is termed a MICROFARAD: this is about the capacity of 3 nautical miles of submarine cable.

Faraday Effect (*Phys.*) The rotation of the plane of polarisation of a beam of plane polarised light when passed through a magnetic field along the direction of the lines of magnetic force. This effect is one of the fundamental illustrations of the theory of Maxwell that light is really an electromagnetic phenomenon.

Faraday's Ice Pail Experiment (*Elect.*) An experiment for determining the amount and sign of induced charges. A charged ball (or similar object) is lowered into a hollow vessel of conducting material (Faraday used a metal ice pail); the outside of this vessel is connected to an electroscope, by means of which the induced charge is examined.

Faraday Tubes (*Elect.*) The part of a dielectric enclosed within a tubular surface formed by a number of lines of force drawn infinitely close together from the boundaries of an area on which there is a unit charge of electricity.

Fareham Reds. *See* BRICKS.

Farina (*Chem.*) Potato starch. *See* STARCH.

Farnese. The name of the Farnese family has been bestowed upon several notable works of art which were formerly located in the Farnese Palace, Rome, but now form part of the collection in the Museo Nazionale, Naples. Amongst them is the FARNESE BULL, a colossal piece of sculpture attributed to Apollonius and Tauriscus of Tralles, and probably executed about the third century B.C. The group represents the chastisement of Dirce by her stepsons for her ill treatment of their mother, Antiope, by binding her (Dirce) to the horns of a bull. It was discovered in the baths at Caracalla in 1546 and restored. The FARNESE HERCULES, another celebrated Greek statue, is in the same museum. The hero is represented undraped, leaning on his club. The muscular development of the figure is remarkable.

Farthingale (*Cost.*) The large hoops, often of extravagant size, which distended a woman's petticoat or skirt, a sixteenth century forerunner of the crinoline of the nineteenth century.

F.A.S. The delivery of goods FREE ALONGSIDE THE SHIP, *i.e.* at the expense of the person consigning them; the cost of loading is not included.

Fasces (*Archæol.*) The emblem of power carried before superior Roman magistrates by lictors. It consisted of a bundle of wands tied up, with an axe in the centre. The blade of the axe projected through the bundle, and indicated that the magistrate had the power of inflicting capital punishment.

Fascia (*Architect.*) A flat member or moulding similar to a band, but larger, usually used in combination with other mouldings. Ionic and Corinthian architraves usually consist of three fasciæ, each of the upper two of which slightly overhangs the one below it. *See* ARCHITECTURE, ORDERS OF; IONIC; CORINTHIAN; ENTABLATURE; *and* ARCHITRAVE.

—— (*Joinery*). (1) The flat surface below the cornice of a shop front. (2) The board to which the eaves gutter is fixed.

Fascines (*Civil Eng.*) Faggots of wood sunk in marshy ground to support structures for which the soft ground will not provide a sufficiently firm foundation. Used where stone is scarce, but it is not a good method. Willow wood is the best, but brushwood from ash, alder, oak, etc., is also used.

Fast Coupling (*Eng.*) A COUPLING (*q.v.*) in which the shafts are permanently fixed together, so that they cannot be thrown in and out of gear with each other.

Fast Head (*Eng.*) The fixed headstock of a lathe, which carries the mandrel with the speed cone and chucks (*q.v.*)

Fast, *or* Fixed, Needle Surveying. Measurement of horizontal angles by means of a circumferenter without the aid of the magnetic needle. Also called BACKING.

Fast Pulley (*Eng.*) A pulley keyed to a shaft and always rotating with it, as distinguished from a LOOSE PULLEY, which revolves freely on the shaft. Fast and loose pulleys are used side by side, so that a belt can be shifted from one to the other to stop or start a machine.

Fast Red (*Dec.*) A term applied to a series of bright reds, known generally as VERMILIONETTES (*q.v.*)

—— *See* DYES AND DYEING.

Fast Yellow (*Chem., Dyeing*). *See* DIAZO REACTIONS.

Fat Colour (*Dec.*) A term applied to stale mixed paint which has become viscid and greasy owing to exposure to the atmosphere. Fat colour is sometimes used for painting rough work, being thinned down with turpentine or benzene before use.

Fat Edges (*Dec.*) A superfluity or bead of paint on the edge or angle of a surface at right angles to the direction in which the brush is being used, *e.g.* on the styles of a door; the result of careless painting. This fault is one of the signs of incompetence. A professional painter guards against fat edges, and draws his brush in an outward direction, so as to avoid it.

Fathom. *See* WEIGHTS AND MEASURES.

Fatigue, Elastic (*Eng., etc.*) *See* ELASTIC FATIGUE.

Fatigue of Materials (*Eng., etc.*) *See* ELASTIC FATIGUE.

Fat Lime (*Build.*) A nearly pure lime (calcined white chalk).

Fat Liquor (*Leather Manufac.*) An emulsified solution of soap and oil in warm water, used for softening mineral tanned leather. Fish or vegetable oils are generally used with a neutral white soap. Sometimes egg yolk is added to make a better emulsion. First used by Ed. Kent on Dongola leather (*q.v.*)

Fats (*Chem.*) Are compounds of glycerine with acids of the $C_nH_{2n}O_2$ $C_nH_{2n-2}O_2$ .... $C_nH_{2n-6}O_2$, and $C_nH_{2n-3}(OH)O_2$ series. The fats are therefore GLYCERINE ESTERS or GLYCERIDES. A fat is also often named from the acid it contains; *e.g.* glycerine (or glyceryl) tristearate is often called tristearin, or simply stearin. The following are the names, modes of occurrence, and formulæ of some of the more important fats: Glyceryl tributyrate (butter), $C_3H_5(OOC.C_3H_7)_3$; glyceryl tripalmitate (palm oil and lard), $C_3H_5(OOC.C_{15}H_{31})_3$; glyceryl tristearate (tallow and lard), $C_3H_5(OOC.C_{17}H_{35})_3$; glyceryl trioleate (olive oil and lard), $C_3H_5(OOC.C_{17}H_{33})_3$; glyceryl trilinoleate (linseed oil), $C_3H_5(OOC.C_{17}H_{29})_3$; glyceryl triricinoleate (castor oil), $C_3H_5(OOC.C_{17}H_{32}(OH))_3$. The first three are solids, the others liquids. On treatment with superheated steam, or on boiling with alkalis or with sulphuric acid, all fats are resolved into glycerine, and the acid united to it. When an alkali is used, the liberated acid unites with it, and the resulting salt is a SOAP. This process of resolution into glycerine and an acid is called SAPONIFICATION. There is an enzyme, LIPASE (STEAPSIN), which has the property of saponifying fats. It occurs in the pancreas and in the seeds of the castor oil plant, the white poppy, and in linseed and maize. The saponification of fats is carried out on an enormous scale in soap making, in the preparation of fatty acids for candle making, and in the preparation of glycerine. Palmitin, stearin, and olein are used on a large scale in the preparation of MARGARINE. The liquid fats (*e.g.* linseed oil) are often called FIXED OILS. Fats are of great physiological importance. Briefly, their functions are: (*a*) To produce heat; (*b*) to produce energy; (*c*) their distribution in the tissues gives rotundity, and through their non-conducting properties serves to retain the heat of the body; (*d*) aid the removal of effete substances; (*e*) play a considerable part

in the conversion of food into tissue. Owing to their being such great heat producers, fats form a large part of the dietary of persons living in very cold countries. *See* FOODS.

Fatsia (*Botany*). *Fatsia papyrifera* (order, *Araliaceæ*). The source of the rice paper of Japan. The paper is prepared by pressing thin sheets of the pith.

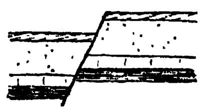
Fatty Acids (*Chem.*) Acids of the series $C_nH_{2n}O$ They are called fatty acids because some of the higher members occur in the fats (*q.v.*) The lower members are liquids; the higher ones, starting with capric acid, $C_{10}H_{20}O_2$, are solids at the ordinary temperature. The lower members are soluble in water; the higher members insoluble in water, but soluble in alcohol and in ether. They all distil in steam. For methods of preparation, see the individual acids, *e.g.* formic, acetic, propionic, butyric, palmitic, and stearic.

Fatty Compounds (*Chem.*) *See* ALIPHATIC COMPOUNDS.

Faucet (*Eng., Build., etc.*) The socket on a cast iron pipe. The name is also applied to a small cock or tap.

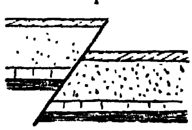
Fault (*Elect. Eng.*) Applied in a special sense by telegraph engineers to a conducting wire, land line, or cable. Faults consist of breakages contact between two lines, electrical connection with the earth (termed WHOLE or PARTIAL EARTHS, according to the degree of completeness of the connection), etc. The detection of faults and the determination of their exact position receive much attention from telegraphists, and many very ingenious methods are employed by which the locality of a fault can often be found within a few yards by an operator perhaps several hundred miles away.

—— (*Geol.*) During the upheaval of part of the crust of the Earth it often happens that a differential movement occurs over a zone of weakness, and the rocks on one side of that zone may be lifted a trifle more than those on the other each time the movement is repeated. Thus a dislocation is caused, and the strata on the same level no longer accord with their counterparts on its opposite side. The downthrow may range up to one of several thousand feet, as is the case with the Pennine Faults, near Appleby.



FAULT.

——, **Reversed** (*Geol.*) In a normal fault the hade or inclination from the vertical of the lower part of the zone of fracture is usually towards the downthrow side of the fault. A vertical shaft passing through the fault could not, therefore, cut the same bed of rock twice. In a reversed fault the hade is in the opposite direction, and it is always the case that some part of the same bed of rock on one side of the fault lies vertically below its counterpart on the other. Reversed faults are generally due to powerful lateral thrusts; but they are sometimes produced by a thrust acting from above downwards.



REVERSED FAULT.

Fault Rock (*Geol.*) The movement, under great pressure, of the rock on one cheek of a fault against the other usually grinds off more or less *débris*, which comes to rest at a lower level, and may be compacted into a breccia (*q.v.*), which is known by the above name. Where the fault fissure is very uneven, masses of considerable size may enter into the composition of the fault rock.

Fe (*Chem.*) The symbol for IRON (*q.v.*)

Feather (*Eng.*) A key, with parallel sides, sunk into and fixed to a shaft. The keyway in the hub of the wheel driven by the shaft makes a sliding fit with the key, so as to allow of relative motion of the wheel and shaft parallel to the axis of the latter. The wheel can slide along the shaft, but must always turn with it.

Feather Edge (*Eng. etc.*) A thin serrated cutting edge which results from the improper grinding of edge tools. Also applied to the "fins" on moulded goods due to the faces of each half of the mould not fitting perfectly, *e.g.* in glass bottles on the sides of the neck and shoulder, owing to a little metal being forced into a thin film between the cheeks of the mould. Mostly found in burst-off bottles or cheap rubber balls and toys.

Feather Edge Boarding (*Carp. and Join.*) Boards that taper or diminish in their thickness from one edge to the other. Used in fencing and in covering the walls and roofs of small wooden buildings, etc.

Feathering Paddles (*Eng.*) Paddle wheels with hinged floats which are caused to enter and leave the water at right angles to its surface. Unnecessary disturbance of the water and consequent loss of power are thus largely prevented.

Feathering Screw (*Eng.*) A SCREW PROPELLER (*q.v.*) whose blades can be turned into a plane parallel to the shaft when the screw is out of use at any time; *e.g.* if the vessel is under sail. Rarely used in modern vessels.

Feathers (*Her.*) Generally those of an ostrich, represented with tips drooping. *See also* PLUME *and* PANACHE.

Feather Trimming (*Textile Manufac.*) Pile fabric woven in stripes.

Feed (*Eng.*) (1) The amount which the cutter of a machine tool is moved at one time, or the rate at which the cutter advances towards the fresh material which is to be removed. (2) FEED WATER (*q.v.*)

—— (*Motor Cars*). The regulation of the supply of petrol to the engine. *See* PETROL ENGINES. In steam cars it refers (1) to the supply of oil to the burner; (2) to the supply of water to the boiler. Both these are usually controlled automatically, but the supply can also be increased or diminished when required by pumps and valves regulated by hand.

Feed Cistern (*Build.*) A small cistern with a ball valve, to supply a boiler.

Feeder (*Foundry*). A mass of fluid metal in a cavity placed at the upper part of a mould and communicating with the space in which the casting is actually formed. It serves as a reservoir of fluid metal to fill up the mould as the casting shrinks or sinks in.

—— (*Met.*) The smaller channels which connect the main channel with the pigs (*q.v.*) when tapping or running off the molten iron from a blast furnace.

—— (*Mining*). A subsidiary vein running into a main vein on the upper side.

Feeding (*Foundry*). Running in a fresh supply of fluid metal during the formation of a large casting. The mould apparently becomes full at the first

pouring, but as the metal solidifies it contracts, and cavities would be left if more metal were not supplied.

Feeding Rod (*Foundry*). An iron rod passed down the holes leading to the cavity of a mould in order to promote the flow of fresh metal during FEEDING (*q.v.*)

Feed Pipe (*Eng.*) The pipe conveying the supply of water to a boiler.

Feed Pump (*Eng.*) A small pump which forces water into a boiler. It is driven either by the engine itself or by a subsidiary or "donkey" engine.

Feed Screw (*Eng.*) A screw used to regulate the feed of a cutting tool.

Feed Water (*Eng.*) The water supplied to a boiler. By measuring its amount, the quantity of steam produced in a given time may be found. Feed water should be clear, free from matter in suspension and in solution.

Feed Water Heater (*Eng.*) A device for warming the feed water, usually by means of the exhaust steam or by the condenser.

Feeling (*Art*). "That visible quality in a work of art which forcibly depicts the mental emotion of the painter, or which exhibits his perfect mastery over the materials of art."—*Fairholt.*

Fehling's Solution (*Chem.*) A solution containing 34·64 grams of copper sulphate, 173 grs. of Rochelle salt, and 84 grams of caustic soda in one litre. The copper sulphate solution is made separately, and a solution of the other substances added to it. It is used as a qualitative and a quantitative test for dextrose, especially in urine. When heated with a liquid containing this sugar, Fehling's solution is reduced; it loses its blue colour, and gives a red precipitate of cuprous oxide. Many other substances reduce Fehling's solution; *e.g.* Lævulose, Maltose, Milk Sugar, Chloral, and Aldehydes generally.

Feigh (*Mining*). Refuse from the ore.

Feints. The first runnings or distillates which come over from a pot still in the distillation of whisky.

Fellmonger (*Leather Manufac.*) One who prepares sheepskins for the tanner by removing the wool. The processes employed to remove the wool is called fellmongering.

Felloes. The rims of wheels: applied chiefly to those which are built up of separate pieces, especially wooden wheels.

Fell of Cloth (*Textile Manufac.*) The last pick of weft forming cloth which is beaten up by the sley; *i.e.* the nearest position of edge of cloth width to reed when weaving in the loom.

Fell Railway (*Civil Eng.*) A railway in which the tractive force is obtained by means of a central rail, which is closely gripped (on both sides) by horizontal wheels attached to the locomotive. This rail has no teeth or projections: but the adhesive power is much greater than in the ordinary system of railway traction, and on the Fell Railway on Mont Cenis trains of thirty-six tons were drawn up a gradient of as much as one in twelve. The two gripping wheels serve as a brake in descending the slopes, and also steady the engine in rounding sharp curves. *See also* MOUNTAIN RAILWAYS.

Felspar (*Min.*) A group of anhydrous silicates of aluminium with varying proportions of calcium, potassium, sodium, and magnesium. These four elements may replace one another in almost any proportion, giving an almost continuous series of varieties, with a gradual transition in physical characters. Some are monosymmetric, some triclinic in their crystalline form. They are an important group of rock-forming minerals. At one end of the series are the POTASH FELSPARS; at the other those which contain much lime. In the middle of the group are the SODA FELSPARS, and between these and either extreme are numerous compounds of an intermediate type. Most eruptive rocks contain one or more of these felspars.

——, **Potash** (*Min.*) A synonym for ORTHOCLASE (*q.v.*)

——, **Soda** (*Min.*) A synonym for ALBITE (*q.v.*)

Felstone (*Geol.*) A name somewhat indefinitely applied to eruptive rocks, allied, in composition, in a general way, to granites. The term is (or was) often used in describing ancient lavas allied to Liparites or to Obsidians, which had become devitrified or stony in texture. It was also used for what would now be termed microgranite, and even for rocks which would now be distinguished as porphyrites. Some of the Scottish rocks formerly classed as felstones are devitrified trachytes or even andesites.

Felt (*Eng.*) Used as a non-conductor of heat for covering steam pipes, etc.

—— (*Paper Manufac.*) An endless woollen blanket used in the manufacture of paper for guiding the wet web of paper to the drying cylinder.

—— (*Woollen Manufac.*) Carded wool made into a wearable texture (*e.g.* carpets, hats, etc.), without weaving, and by fulling or felting.

Felting. The tendency which fibres have to interlock. This tendency is turned to advantage. *See* FELT.

—— (*Woollen Manufac.*) The process of shrinkage which wool and woollen cloths undergo when subjected to moisture, heat, and pressure.

Female Gauge (*Eng.*) A hollow gauge; *i.e.* one used for measuring and adjusting the outside of a piece of work.

Female Screw (*Eng.*) A hollow screw or a nut having an internal thread.

Femme (*Her.*) The heraldic term for wife.

Femur (*Architect.*) *See* MEROS.

—— (*Zoology*). The thigh bone of the leg. It has a rounded lateral head and two prominent ridges—TROCHANTERS—at the upper end.

Fence (*Eng., etc.*) A guide used to keep a cutting tool, and the work operated on, in their proper relative positions. It may be used where the work is moved, as in a circular saw, or where the tool moves, as in a plough (*q.v.*) or a rebate plane (*q.v.*)

Fencing In (*Eng.*) The guarding of moving parts of machines to prevent injury to workmen. It is required by the Factories Acts.

Fender (*Carp.*) A large piece of timber outside the sill of a gantry to protect the structure from injury by passing traffic.

Fenders (*Archæol.*) These were made of rushes, etc., and were placed round wax seals in the fifteenth century to protect them.

Fender Wall (*Build.*) The wall that carries the hearth on the ground floor of a building.

Fenestration (*Architect.*) The arrangement of the windows and other openings in a façade.

Fennel (*Botany*), *Fœniculum officinale* (order, *Umbelliferæ*). A common plant formerly much used as a pot herb. An aromatic oil is distilled from the fruits.

Fenugreek (*Botany*), *Trigonella fœnum græcum* (order, *Leguminosæ*). The seeds are used in veterinary medicine, and as a condiment in India.

Fer de Moline (*Her.*) Another term for MILL RIND; the iron clamp by which a millstone was fixed.

Feretory. A small shrine, often very richly ornamented, in which are placed relics. A portable shrine.

Fergusonite (*Min.*) A metaniobate and tantalate of yttrium, erbium, cerium, uranium, and iron. Tetragonal, hemimorphic, in small brownish black crystals, disseminated in quartz from near Cape Farewell, in Greenland.

Fermata (*Music*). Pause.

Fermentation. The chemical change brought about in organic substances of the most varied kind by: (1) Moulds, such as *Penicillium glaucum*; (2) Saccharomycetes, such as yeast; (3) Bacteria, such as the *Bacillus butylicus*; (4) Enzymes (*q.v.*) The members of the first three classes are known as ORGANISED FERMENTS, because they are living organisms of definite structure. The substance undergoing fermentation is part of the food for the organism, and the substance produced is a waste product of the organism. For an organised ferment to work properly, it must have all the elements necessary to build up its organism in accessible form. The fermenting substance must not be too concentrated, the temperature must be suitable, and the product of fermentation must be removed after it has attained a certain concentration, or the process will stop. The following are examples of fermentation:—ALCOHOLIC FERMENTATION. When brewers' yeast (*Saccharomycetes cerevisiæ*) is added to a solution of cane sugar (which is not too strong, and contains traces of potassium, ammonia, magnesium, calcium, sulphates, phosphates), and the temperature is kept between 25° and 30° C., the sugar is converted by the enzyme invertase, which is present in the yeast, into equal quantities of dextrose and lævulose; the yeast then ferments these two sugars, the dextrose first and the lævulose afterwards, to alcohol and carbon dioxide. Other products are formed also, but in much smaller amount; *e.g.* glycerine, succinic acid, and higher alcohols. These are probably formed by other organisms than the *S. cerevisiæ*. *See also* ALCOHOL *and* ZYMASE. ACETIC ACID FERMENTATION: This is brought about by *Mycoderma aceti* in dilute solutions of alcohol. *See* ACETIC ACID. The souring of wine and beer are examples of this fermentation. LACTIC ACID FERMENTATION: This fermentation is set up in milk by a large number of bacteria, the most important of which is *B. acidi. lactici*. These bacteria ferment the milk sugar (lactose), and the lactic acid produced coagulates the milk (*i.e.* the casein); they can also produce lactic acid from cane sugar and dextrose. *See* LACTIC ACID. The change of urea in urine to ammonium carbonate is due to a *Micrococcus*. For other examples *see* BUTYRIC ACID, SUCCINIC ACID, MANDELIC ACID, *and* LEATHER MANUFACTURE.

Ferments. *See* FERMENTATION.

Feronia (*Botany*). The elephant apple tree (*Feronia elephantum*; order, *Rutaceæ*) of India yields a gum resembling gum arabic. Its wood is also valuable.

Ferricyanide Printing Process (*Photo.*) Paper is coated with a solution containing potassium ferricyanide and a ferric salt (ammonio-citrate). Exposure under a negative (or tracing, etc.) renders the salts insoluble, where they have been acted upon by light. The process is completed by washing with water, when the salts which have not been acted on are removed, leaving white lines on a blue ground.

Ferricyanides (*Chem.*) Salts of HYDROFERRICYANIC ACID, $H_3Fe(CN)_6$ (*q.v.*)

Ferrocyanide Printing Process (*Photo.*) Paper is coated with a solution containing citrate of iron and ammonia, and ferric chloride. Exposure is made in accordance with the ordinary method of contact printing, and the print is developed with a solution of potassium ferrocyanide. When the details have become clear, the print is rinsed and put into dilute hydrochloric acid, giving blue lines on a white ground.

Ferrocyanides (*Chem.*) Salts of HYDROFERROCYANIC ACID, $H_4Fe(CN)_6$ (*q.v.*)

Ferromanganese (*Met.*) A name applied to pig iron with a high percentage (20 or more) of manganese. *See* IRON.

Ferrosoferric Oxide (*Chem.*) TRIFERRIC TETROXIDE, Fe_3O_4. *See* IRON COMPOUNDS *and* MAGNETITE.

Ferruginous. Carrying or charged with iron.

Ferrule. (1) A short tube into which two parts of an object fit. (2) A wooden tube or ring used for making a watertight joint between a tube of a surface condenser (*q.v.*) and the plate into which it fits. (3) An iron ring used in foundry work to support the end of a core.

—— (*Watches, Clocks*). A small pulley used for rotating drills, or pieces of work that have to be turned or otherwise operated on.

Ferrum, Ferric, Ferrous (*Chem.*) *Ferrum* is the Latin name for iron; from it is derived the symbol FE for iron. This metal forms two series of salts, *viz.* (1) FERRIC SALTS, in which iron is trivalent (*see* VALENCY); (2) FERROUS SALTS, in which it is divalent—*e.g.* ferric chloride, $FeCl_3$, and ferrous chloride, $FeCl_2$. *See* IRON COMPOUNDS.

Ferula (*Botany*). A genus of the order *Umbelliferæ*. ASAFŒTIDA and GUM GALBANUM (*q.v.*) are derived from certain species.

Fescue Grass (*Botany*). *Festuca sp.* (order, *Gramineæ*). A large group of grasses of over ninety species. Many of them are valued as meadow and pasture grasses.

Fesse (*Her.*) One of the ordinaries. It is a band occupying the central third part of a shield. *See also* HERALDRY.

Fetter Lock (*Her.*) A padlock and leg iron.

Fettler (*Foundry*). A workman who trims up castings after they are taken from the mould.

Fettling (*Eng., Met., etc.*) (1) Trimming up castings; removing fins, cores, etc. (2) Material used for lining puddling furnaces. It usually consists largely of iron oxides. *See also* BULL DOG.

Fettling (*Woollen Manufac.*) The operation of cleaning the card clothing in scribbling and carding machines.

Fibres (*Botany*). Plant cells which have lost their protoplasm and have their walls thickened and lignified. The cells are usually pointed at the ends, and are often of great length. They constitute the elements of the hard bast (*q.v.*)

Fibrin (*Chem.*) A substance of unknown formula produced when blood clots. It forms tenacious elastic fibres, and is coagulated by heat, alcohol, and prolonged contact with salts. It readily dissolves in acids.

Fibrinogen (*Chem.*) A jellylike tenacious solid of unknown formula: insoluble in water, soluble in salt solutions and in alkalis. It occurs in blood, and is converted by an enzyme (thrombin) present in the white corpuscles into fibrin (*q.v.*) and a small quantity of another albumin.

Fibrous Plaster (*Dec.*) Plaster ornaments usually backed up with canvas and ready for placing in position by the plasterer.

Fibrovascular Bundles (*Botany*). The strands of conducting tissue in the root, stem, and leaves of a plant. The bundle may consist of wood (XYLEM) only, or wood and soft bast (PHLOËM), or CAMBIUM may be present in addition to wood and bast. The prefix "fibro" indicates the presence of hard bast associated with the bundle.

Fibula (*Archæol.*) A clasp or brooch (*q.v.*)

—— (*Zoology*). One of the two bones forming the lower part of the leg, *i.e.* the part between the knee and the ankle. The other bone is the TIBIA (*q.v.*)

Fictile (*Pot.*) Pertaining to pottery or the potter's art.

Ficus (*Botany*). An important genus of the order *Moraceæ*. Many species yield economic products, such as figs (from *Ficus carica*), indiarubber (from *Ficus elastica*). The banyan is also a species of this genus.

Field (*Elect.*) The ELECTRIC FIELD is the space in the neighbourhood of an electrified body, or bodies, in which electrical phenomena are produced by the body. A MAGNETIC FIELD is a space having the same relation to a magnetised body. In both cases the medium filling the space is traversed by the LINES OF FORCE (*q.v.*), and is subject to stresses, which are of the nature of tension along the lines of force and pressure at right angles to them.

—— (*Her.*) The surface of the shield.

—— *or* **Field of View** (*Optics*). The space or area which is visible at one time through a lens or system of lenses.

Fielded Panel (*Carp.*) A raised panel with a flat surface in the centre.

Field Magnets. The magnets producing the lines of force which are cut by the conductors of an armature. *See also* DYNAMO.

Field of View (*Astron.*) The portion of the heavens visible in a telescope.

Field's Syphon Flush Tank (*Hygiene*). Field's flush tank is one of the best in use for automatically flushing sewers and drains. It can be adapted for either purpose. If for sewers, it is built of brickwork; and if for drains it is made of galvanised iron to any required size. It consists of a main tank, with a small chamber beneath. Into this chamber the long leg of the syphon dips after passing through the floor of the tank above. Covering this pipe in the interior of the tank is a bell shaped arrangement, which passes nearly to the bottom. This constitutes the syphon. A tap from the rising main is connected with the tank, and the interval between each flush is regulated by the supply of water from the tap.

Field's Tubes (*Eng.*) *See* BOILERS.

Fiery Mine. One in which explosive gases (FIRE DAMP) are given off.

Fig (*Botany*). *Ficus carica* (order, *Moraceæ*). The dried fruit forms the well known dietary article. It is imported from Smyrna.

Figging (*Soap Manufac.*) A characteristic spotted appearance in soft soaps due to the presence of specks of stearate of potash. Supposed to be an indication of quality, though why is not quite clear, as starch, clay, or steatite is sometimes used to produce a figged appearance in soaps which contain no tallow or other source of palmitic or stearic acids.

Figured (*Her.*) When the human visage is shown, as on the sun.

Figured Bass (*Music*). The bass part only of a composition, with figures above to denote the chords to be added.

Figured Harness (*Silk Manufac.*) *See* MOUNTURE.

Figurine (*Art, etc.*) Literally, a small figure. Applied to small sculptured figures and statuettes.

Filature (*Silk Manufac.*) A superior quality of raw silk reeled by European methods.

File (*Her.*) Another term for LABEL (*q.v.*)

Files. The file is one of the principal hand tools of the engineer and of other metal workers. It consists of a steel blade or body, of very variable form and size, fixed into a wooden handle. TEETH of suitable form and size are cut on the blade, and the latter is hardened and tempered. Files may be classified and described according to their form, use, and the nature of their teeth. Most of the terms used to describe the form require no explanation, *e.g.* parallel, taper, round, half round, three sided, etc. PILLAR and COTTER FILES are narrow files of rectangular section. A RIFFLER is a bent file, used for filing a concave surface. KNIFE EDGED FILES have a section of the form of a narrow V. FEATHER EDGED FILES have a rhombic section, with two very acute and two very obtuse angles. The teeth or CUT of a file may be described as ROUGH, MIDDLE, BASTARD, SECOND CUT, SMOOTH, or DEAD SMOOTH, according to the number of teeth per inch, which range from 12 or 14 to 100, or even more. The teeth of an ordinary file form two sets crossing each other at an angle; this arrangement constitutes the DOUBLE or CROSS CUT. A file with a single set of teeth is usually termed a FLOAT. A SAFE EDGED FILE is one which has one side or edge without teeth. RASPS may be conveniently grouped with files, though their use is chiefly confined to the wood working trades. The form and process of manufacture are similar to those of files; but the teeth consist of "burrs" thrown up by a pointed punch, instead of the straight-edged chisel which is used in making the teeth of a file.

Filigree, Filagree. Delicate metallic lacework, generally gold or silver, formed into ornaments. Filigree work was introduced into Europe from the East by the Italians. Old filigree work was generally ornamented with small beads.

Filler (*Dec.*) *See* FILLING UP.

Fillet (*Architect.*) A small flat face used to separate mouldings or to strengthen the upper edge of a crowning moulding. The narrow band separating the flutes of a column or pilaster. It is also known as a LISTEL.

—— (*Bind.*) A tool used in finishing to produce single, double, and other gilt lines. In England fillets consist of brass wheels which are heated and rolled over the work. On the Continent these tools are mostly flat, and are believed to produce brighter gilding.

—— (*Carp.*) A narrow strip of wood: a flat band.

—— (*Coins*). The ribbon of metal from which the blanks (*q.v.*) are punched.

—— (*Cost.*) A narrow band, generally of some woven material, used to keep the hair in place. Such a band was worn by both men and women in Ancient Greece. *Cf.* DIADEM *and* DIADUMENUS.

—— (*Eng., etc.*) A general term for a narrow band or strip of material, usually projecting above the general level of a surface.

—— (*Her.*) The diminutive of the CHIEF (*q.v.*) *See also* HERALDRY.

Fillet Ground (*Lace Manufac.*) A net with absolutely square holes, similar to canvas, but more defined and "lacey" in appearance. Made upon all descriptions of lace machinery.

Filleting (*Build.*) A band or strip of cement in the angle where the slates on a roof touch the wall, instead of step flashing (*q.v.*)

Filling (*Soap Manufac.*) The treatment of soaps to enable them to carry an excess of water or other weight giving materials, such as paraffin, and petroleum hydrocarbons, without rendering the soap too soft for ordinary use. Cold-made transparent soaps are often heavily filled, and also sugared.

—— (*Woollen Manufac.*) The American term for WEFT YARN.

Filling Up (*Dec.*) The process of bringing a surface to a level before painting or between the application of the coats. Small inequalities are stopped (*q.v.*) with putty, but filling up is always necessary when the surface is uneven. A good filler for a plastered surface is made by mixing fine plaster of Paris, whiting, and warm size. For paint work a mixture of white lead, yellow ochre, and gold size answers well, but a patent filler, manufactured at Merton, is much superior when hard wood such as oak is to be "natural finished" (*q.v.*) A paste filler composed of starch, silex, or some other fine substance, mixed with varnish, etc., is used to fill the grain of the wood.

Fillister (*Carp.*) A rabbet plane with movable fence.

Film. Any very thin layer of material, especially of a flexible nature.

—— (*Photo.*) (1) A thin layer of celluloid coated with sensitive emulsion, and forming a dry plate on which negatives can be made. (2) The actual layer of sensitive emulsion, whether it be supported on glass, paper, or any other material.

Filter. *See* FILTERS.

Filterpress (*Chem. Eng.*) A series of recessed plates, separated by a filter cloth, are arranged in a horizontal frame, which carries the plates or sections. The material to be filtered is passed under pressure into the sections until a solid cake is formed in the plate-chambers, the liquid portion passing away through the filter cloths into a common collecting trough. These presses have been called into existence by the need in the chemical and allied industries for rapid filtration in manufacturing operations. In conjunction with the centrifugal hydro-extractor, the perfecting of these presses constitutes one of the most marked advances in the development of chemical plant by chemical engineering. They are very extensively used for pressing sewage sludge, the lime mud from causticisers, the separation of precipitated pigments in the colour industry, the removal of water from pulp in paper manufacture, and numerous other applications for the separation of solids from liquids in the soap, candle, oil cake, paraffin wax, tar distilling, and general chemical industries. The most modern presses of a certain class provide for the "cake" being washed free from mother liquor *in* the press, without taking the plates apart or handling the material. This is a feature of great importance in some processes, such as the manufacture of zinc white, lithopone, and precipitated chalk, where the separation of the solid in a pure state is the primary object of filtration.

Filters (*Chem., Eng.*) Many special types of filter are employed for the filtration of water for industrial purposes and the purification of manufacturers' waste waters. The majority consist of concrete or iron tanks containing a graduated filter-bed of clinker, gravel, and fine sand, but with special mechanical arrangements for distributing the water evenly over the bed, and periodically washing away the collected impurities. This is effected (after stopping the flow of water) by rapid back-flushing, the fine sand often being loosened and stirred by revolving arms, so that the bed is quickly cleansed with a small volume of water. There are at least six well-known systems in operation, and in some the filter-tank is covered so that the filtration (by gravity) may be accelerated by pressure.

—— (*Hygiene*). To properly perform their function, filters should prevent the passage of pathogenic organisms through their substance; *i.e.* they should sterilise the water. Public supplies are purified by means of beds of sand and gravel. These vary in depth. In the London Water Companies' filters the depth of sand ranges from 1ft. 6in. to 4ft. 3 in. The selection of a domestic filter is of considerable importance, as the use of one which is not competent gives a false security, and may play a conspicuous part in the spread of disease. The best domestic filters are the Pasteur-Chamberland and the Berkfeld.

Filtration. The process employed to separate solid particles from a liquid. In the laboratory circular sheets of unglazed paper are used, the paper being folded into four and supported in a glass funnel. When the liquid attacks paper, a plug of asbestos, guncotton, or glass wool is used. If it is desired to hasten the filtration, the paper may be supported in the funnel by a small platinum cone, and the funnel fitted into a vessel from which the air can be pumped out. In filtering water on the large scale for use in towns, sand and stones are used; a typical filter of this kind is: fine sand, 24 in. in depth; gravel, 12 in.; and boulders, 12 in. The action of a filter of this description is, however, not merely mechanical—a slime forms at the top of the sand in which bacteria grow, using up the bacterial food supply in the water, while the products of bacterial life pass through with the water and largely stop

the growth of bacteria through the filter. In such filters the water is introduced *from below.*

Filtration (*Chem., Eng.*) The industrial applications are many and varied. *See* FILTERPRESS *and* FILTERS.

Fimbria. A fringe.

Fimbriated (*Her.*) Bordered with a narrow band or edge; *e.g.* the white edging which borders the Cross of St. George and the Cross of St. Patrick on the Union Jack or flag of England. *See* UNION JACK.

Fin (*Eng.*) A thin projecting edge on a casting or forging formed by metal forcing its way between the two halves of the mould or die in which the object was cast or forged.

—— (*Zoology*). A flattened expansion of the body in fishes. The paired fins correspond to limbs, while the unpaired fins are merely special swimming organs.

Finder (*Astron., etc.*) A small telescope of low power with a wide field of view, which is attached to large telescopes in such a manner that when a star is approximately in the centre of the field of the finder it is somewhere within the field of view of the large instrument.

Fine Metal *or* **White Metal** (*Met.*) The MATT *or* REGULUS in the later stages of copper smelting, containing 60 to 80 per cent. of copper (*q.v.*)

Fine Stuff (*Build.*) Slaked lime and fine sand, in the proportion of one to two.

Finial (*Architect.*) An ornamental feature at the top of a pinnacle, gable, etc. It is frequently carved to represent a bunch of foliage.

Finish (*Art*). The result obtained by a careful attention to detail in the execution of a work of art.

—— (*Build.*) The last coat of paint, plaster, etc., laid upon any surface.

—— (*Woollen Manufac.*) A special kind of routine of finishing a woollen fabric to obtain a short and lustrous nap or pile on the face by successive boiling and raising.

Finishing (*Bind.*) The gilding, blind tooling, and other ornamentation of book covers.

—— (*Leather Manufac.*) This process includes the seasoning and glazing of leather.

Finishing Cut (*Eng.*) A very fine cut taken in a lathe or machine tool in order to produce a good surface on the finished work.

Finishings (*Build.*) The name given to the joinery fixed in a building.

Finishing Stove (*Bind.*) A gas stove having a large circular plate top and an outside ring. The handles of finishing tools rest upon this ring while the metal ends are being heated on the plate.

Fiords (*Geology*). A term loosely applied to any steep-sided valley, shaped, in the first instance, by rain and rivers, and afterwards lowered so that the sea has been admitted. Those of Norway are typical. In many instances the bottom of a fiord is deeper in the middle than at the seaward end, so that such depressions are more of the nature of lake basins which have been carried, by local subsidence of the Earth's crust, beneath the sea. It has been proposed recently to limit the term fiord to cases of this kind. Drowned valleys in most districts that have been glaciated would then come under this designation. *See* GLACIER.

Fir. *See* WOODS.

Fire Bars (*Eng.*) Castings forming the grating at the bottom of a firebox or furnace. They are made separately to admit of easy removal.

Fire Beacon (*Her.*) An iron basket, with contents alight, on a pole against which leans a ladder.

Firebox (*Eng.*) The part of a boiler which actually contains the fire. *See* BOILERS.

Firebrick Arch (*Eng.*) The structure in a locomotive boiler which deflects the flames and hot gases backward. *See* BOILERS.

Firebricks. *See* BRICKS.

Fireclay (*Geology*). A term applied to any kind of clay that will stand exposure to the high temperature within a furnace without fusing. The essential feature in the composition of such a rock is that it shall contain little or no alkaline matter or any other substance that would tend to act as a flux. Fireclay sometimes occurs in association with beds of coal, but there is no necessary connection between the two kinds of rock. *See* DINAS CLAY.

Fire Cracked (*Pot.*) Ware is described as fire cracked if when removed from the bisque oven a crack is found which is traceable to the bisque firing, and which was not present in the clay stage of its production.

Fire Damp (*Mining*). The coal miner's name for METHANE (*q.v.*)

Fire Damp Cap (*Mining*). The name given to the mantle of burning methane (fire damp) which surrounds the flame of a Davy safety lamp in a fiery mine.

Firedog. *See* ANDIRON.

Fire Door (*Eng., Met., etc.*) The door of a furnace or boiler.

Firelock (*Arms*). An early form of gun, with a lock for producing a spark to ignite the priming: used first in the seventeenth century. The earliest form of gun of this kind was a WHEEL LOCK, the later kind a FLINT LOCK.

Fire Opal (*Min.*) A variety of opal (*q.v.*) showing red and yellow flashes. From Cornwall, Mexico, Guatemala, and the United States.

Fireplaces, Open (*Hygiene*). As a means of heating, open fireplaces are the most expensive in use. They are extravagant because the heat is not all utilised, nor is it distributed uniformly; they give up to the room only a very small portion of the heat yielded by the fuel, the remainder passing up the chimney. They, however, have the great advantage of providing an excellent means of ventilation, and are certainly pleasant in effect. In constructing fireplaces, the following principles, laid down by Teale, should be aimed at: (*a*) As much firebrick and as little iron as possible should be used; (*b*) the back and sides should be of firebrick; (*c*) the back of the fireplace should lean over the fire, while the throat of the chimney should be contracted; (*d*) the bottom of the fireplace should be deep; (*e*) all slits in the bottom of the grate should be as narrow as possible; (*f*) the bars in front should be narrow; (*g*) the space between the floor and the bottom of the fireplace should be closed in front by a close fitting iron shield called an economiser.

Fire Prevention. *See* PREVENTION OF FIRE.

Fireproof Paint (*Dec.*) Paints of various colours in which asbestos is mixed to prevent their ready combustion. The paints are increasing in demand, especially for use in large buildings. So-called fireproof structures are frequently rendered very inflammable by the nature of the interior work and fittings, which, when painted in the ordinary way, cause a spread of fire at the most important point, namely at its inception. CARBORUNDUM (*q.v.*) promises to be very useful in this connection.

Fire Test. *See* FLASHING POINT.

Fire Tube Boiler (*Eng.*) A boiler in which the tubes carry the hot gases, as in a locomotive boiler. Also called a MULTITUBULAR BOILER. It is to be distinguished from an ordinary tubular boiler or a water tube boiler. *See* BOILERS.

Firing (*Eng.*) (1) Attending to the fire in a furnace or boiler. (2) The undue heating of any part of a machine through friction. (3) A general term for ignition, especially the IGNITION OF THE CHARGE (*q.v.*) in gas engines.

—— (*Pot.*) The process of exposing the clay goods to the heat of the kiln.

—— *or* **Ignition Chamber** (*Eng.*) The space in which ignition occurs. *See* GAS ENGINES.

Firing Tools (*Eng., etc.*) The tools used in stoking and trimming a fire.

Firmer Chisel (*Carp., etc.*) A stout chisel, stronger than a paring chisel (*q.v.*), but slighter than a mortising chisel. It is intended to be used by the hand alone, and not, as a rule, with a mallet.

Firmer Gouge (*Carp., etc.*) A gouge similar to a firmer chisel (*q.v.*) in strength, and used in a similar manner.

Firring *or* **Furring** (*Carp.*) *See* FURRING.

Fir Seed Oil. A drying oil made in limited quantities from the seeds of various pine trees. It is sometimes used in paint and varnish making.

Fir, Silver. *See* WOODS.

First Point of Aries (*Astron.*) The point of intersection of the Ecliptic and Celestial Equator, through which the sun passes from the south to the north of the equator. The other point of intersection is called the FIRST POINT OF LIBRA.

First Point of Libra (*Astron.*) *See* FIRST POINT OF ARIES.

First Proof (*Engrav., etc.*) A proof taken from a plate before the inscription, etc., has been engraved upon it. Proofs of this description are generally signed by the engraver, and are of greater value than those printed subsequently. Sometimes termed "proofs before letters."

First State (*Engrav.*) The term is applied to a proof printed from a plate which has not received the final touches, or to a proof, whether finished or not, which differs from the proofs of the second printing.

First Water (*Gems*). Of the highest quality or finest lustre. Applied principally to pearls and diamonds.

Fir Wool (*Botany*). A material in the form of wadding or sheets, made from cotton wool impregnated with an extract of pine leaves. Formerly fir wool was made from the leaves themselves.

Fish (*Her.*) All species are used as charges.

Fish Bellied (*Eng.*) Girders, etc., which are curved so that their lower surface, seen in profile, is convex downwards.

Fished Joint (*Eng.*) A joint made between two rails, beams, etc., by drilling bolt-holes in the ends, bringing the ends together, laying on each side a plate (termed FISH PLATES) having holes corresponding to those in the ends of the rails or beams, and bolting the whole together by FISH BOLTS, or long bolts passing right through the rail and the two plates.

Fish Plates *or* **Fishplates** (*Eng.*) A kind of tie-plate chiefly used for connecting the ends of railway "metals" or rails. *See* FISHED JOINT.

Fishtail Burner. A gas burner giving a flat luminous flame.

F.I.T. Free in Truck; *i.e.* goods which are loaded on trucks at the expense of the consigner.

Fitch (*Dec.*) A small hoghair brush used in delicate decorative work such as lining, picking out ornaments, enrichments, etc. Fitches are made round and flat and also with a bevelled edge, the latter being used for lining (*q.v.*)

Fitchée (*Her.*) Pointed at the end, so that the object may be fixed in the ground.

Fitter (*Eng.*) The workman who carries out the bulk of the hand work in engineering shops. The fitters produce the most accurately finished work on parts which have been more or less correctly shaped with the machine tools.

Fitter's Bench (*Eng.*) A strong bench for handwork.

Fittig's Reaction (*Chem.*) A method of preparing homologues (*see* HOMOLOGOUS SERIES) of benzene. Clean sodium is dropped into a mixture of phenyl iodide (iodobenzene) and an alkyl (*q.v.*) iodide dissolved in dry ether—the flask being kept cool. The following reaction takes place when ethyl iodide is used: $C_6H_5I + C_2H_5I + 2Na = C_6H_5C_2H_5 + 2NaI$.

Fitting (*Eng.*) The hand or bench work involved in the construction and finishing of metal objects in mechanical engineering shops.

—— (*Soap Manufac.*) The treatment of curd soap to remove excess of free alkali. After the "made" soap has separated from the ley, the paste (*q.v.*) is treated as wet steam, which dilutes the ley still entrained in the soap grains. When the desired stage of dilution is reached (coarse fit, fine fit, etc.), the whole stands for about twelve hours, and separates into three layers: at the bottom NEGUR, composed of weak ley, dirt, metallic coloured soaps, and suchlike impurities; at the top a solid crust or FOB of frothy soap; and in the middle the NEST SOAP. Genuine fitted soaps usually contain considerably more water than curd soaps, *i.e.* about 30 per cent. if unsilicated.

Fittings (*Eng.*) (1) The smaller parts of a machine, etc., constructed separately and afterwards added to the main part. (2) The accessories on a boiler-shell, such as safety valve, gauge glass, etc.

Fitting Shop (*Eng.*) The shop where the hand work or FITTING is carried on. Its necessary appliances are a vice, hand tools, gauges, and measuring tools.

Fixed Cutters (*Carp., etc.*) Large tools resembling plane irons fixed in a bench, over which wood is drawn by mechanical power for planing up. The arrangement corresponds to a large inverted plane which is kept fixed while the wood is moved.

Fixed Eccentric (*Eng.*) An ECCENTRIC (*q.v.*) keyed to its shaft; now almost universally used.

Fixed Expansion (*Eng.*) An arrangement or adjustment of the SLIDE VALVE (*q.v.*) of an engine by which the cut off always occurs at the same instant, *e.g.* at one-third of the stroke. An adjustable cut off allowing variable expansion is preferable, as the amount of steam used in each stroke can then be modified to suit the power which the engine is required to develop.

Fixed Oils (*Dec.*) The true oils, *i.e.* glycerides, such as linseed, walnut, poppyseed oils, which are not changed by heating and distillation. They thus differ from the ESSENTIAL OILS (*q.v.*) or volatile spirits, and harden on exposure to the air.

Fixed Pulley (*Eng.*) A pulley keyed to its shaft.

Fixing (*Photo.*) The removal of the unaltered silver salts from the film after development, carried out by means of a solution of sodium thiosulphate (hypo) or with potassium cyanide. These act by forming a soluble double salt with the silver, which readily diffuses out in the washing water.

Fixing Fillets (*Build.*) Slips of wood built in the joints of brickwork to which the joinery is fixed.

Flag *or* **Flagstone.** A paving stone, especially one of those natural stones (commonly sandstone) which split easily into flat slabs suitable for paving. *See* FLAGSTONES.

Flagstones (*Geol.*) Thin beds of sandstone which can be easily quarried in the form of slabs suitable for paving stones or for rough slating. In the north of England a flagstone quarry is often referred to as a slate quarry. The best flagstones are those from the Orcadian or Middle Old Red Sandstone of Caithness and Orkney. Next to these are the Carboniferous Flagstones of the north and midland counties of England. Some of the Jurassic rocks also yield good flagstones.

Flanches (*Her.*) Always in pairs, and formed by two curved lines extending from upper angles of shield to the respective base points, the curves being inwards.

Flake White (*Paint. and Dec.*) The name given to pure, finely ground white lead when especially prepared for artists' use.

Flaking (*Dec.*) A defect in distemper (*q.v.*) in which the paint flakes off, owing to imperfect adhesion with the surface to which it is applied. May sometimes be avoided by adding sulphate of zinc to the distemper.

Flamboyant (*Architect.*) The name given to the later period of French Gothic architecture, contemporaneous with English Perpendicular Gothic. The principal characteristic of Flamboyant work is the flamelike form of the window tracery. In late English decorated work Flamboyant tracery is occasionally used, but this can always be distinguished from the French by the mouldings. *See* DECORATED.

Flame (*Chem.*) A flame is gaseous matter raised to such a temperature by chemical action that it is incandescent. Two kinds of flame may be distinguished—the luminous and non-luminous. The flame of a candle may be taken as a type of the former, and the flame of a Bunsen burner or of a gas stove may be taken as a type of the latter. A candle flame can be seen to consist of (*a*) a blue region at the base of the flame, forming the outside part of the flame; (*b*) a dark inner region surrounding the wick and extending to some distance above it; (*c*) a luminous region exterior to the dark region and interior to the blue region at the base; (*d*) a brownish, nearly non-luminous sheath of small extent surrounding the luminous region above and merging into the blue towards the lower part of the flame. The dark inner region (*b*) consists of gases formed by vaporisation of the fat of the candle; these gases are undergoing decomposition owing to the heat generated by the combustion going on in the two regions (*a*) and (*d*) exterior to the dark zone. These gases can easily be syphoned off by a piece of narrow gas tubing and burnt. This dark region (*b*) is comparatively cool. The highly luminous region is produced by incomplete combustion of the gases of the dark region; here hydrocarbons, rich in carbon, are produced, and burn with a luminous flame, and solid carbon separates and is raised to incandescence by the high temperature produced by the processes of combustion occurring in this region. In the outermost zone the combustion is practically completed, and this is the hottest part of the flame; a thin platinum wire introduced just within this region can be melted. A luminous gas flame is very similar to the candle flame just described. A non-luminous flame can be obtained by burning coal gas in two ways: (1) mixed with air or oxygen; (2) mixed with gases, such as nitrogen, carbon dioxide, hydrogen, etc. Hence it appears that non-luminosity is produced by the more complete combustion which occurs on burning coal gas mixed with oxygen, and also by the diluting action of inert gases. In the Bunsen flame or gas stove flame these two causes act together. The diluting gas nitrogen tends to lower the temperature of the flame; but the more complete combustion which goes on throughout the flame more than counterbalances the cooling effect of the nitrogen. In the Bunsen or gas stove flame there are only two parts: an inner dark or bluish part of unburned gas corresponding to the dark region (*b*) in the candle flame; an outer, nearly non-luminous part where combustion is complete. The heated gases of the inner region are capable of bringing about REDUCING REACTIONS; that is, of abstracting oxygen from metallic oxides, etc. The top of the outer region and the outer margin of it can effect OXIDISING ACTIONS, *e.g.* change a metal to its oxide. A blowpipe flame resembles a Bunsen flame. In the coal-gas flame the outer part, where combustion is most active, is positively electrified, while the inner part is negatively electrified. The gases escaping from nearly all flames are ionised, and thus have the power of discharging electrified bodies. When certain metallic oxides are brought into a hot, non-luminous flame, they become highly incandescent; *e.g.* the oxides of magnesium (MgO), aluminium (Al_2O_3), calcium (CaO), etc. The LIMELIGHT and the WELSBACH BURNER are applications of this fact: in the former the oxyhydrogen flame or the oxygen coal-gas flame is made to impinge on a cylinder of chalk or lime; in the latter case an ordinary non-luminous air-coal-gas flame is made to play upon a mantle composed of 99 per cent. of thorium oxide and 1 per cent. of cerium oxide. The nitrates of these metals in the proper proportions are dissolved, and a suitable fibre soaked in the solution; on burning away the fibre, a skeleton of the oxides remains.

Flame Plates (*Eng.*) The part of a firebox on which the flames of the fire impinge.

Flame, Sensitive (*Phys.*) A gas flame, when the pressure of the gas has been increased until the flame is on the point of flaring, is very sensitive to sounds, especially those whose pitch is very high. Such a flame is frequently used as a detector of high-pitched notes. The gas pressure should be about 8 in. of water, *i.e.* four times the ordinary pressure of the house supply of coal gas.

Flang (*Mining*). A Cornish name for a two-pointed pick.

Flange (*Eng., etc.*) A projection (usually with at least one plane surface) running round an object, *e.g.* the disclike projection at the end of a cast iron steam pipe, by means of which it is fixed to the adjoining length of pipe or the projection running along a girder (*q.v.*) The term is also applied generally to any continuous flat surfaced projection which is (usually) at right angles to the main surface of the object to which it is attached.

—— *or* **Flanged Chuck** (*Eng.*) A face plate, *i.e.* a broad, disc-like chuck whose plane surface is at right angles to the axis of rotation.

Flange Coupling (*Eng.*) A coupling or connector between two lengths of shafting, which consists of two castings resembling face plates with collars; each is keyed to the end of its piece of shafting, and the two are fastened together by bolts.

Flanged Beam *or* **Girder** (*Eng.*) A beam which in section is in the form of a letter I.

Flanged Nut (*Eng.*) A NUT (*q.v.*) with a flange resembling a WASHER (*q.v.*), but made in one piece with the nut. It is sometimes more convenient than a separate washer.

Flanged Pipe (*Eng.*) A pipe having a flange (*q.v.*) at the end by means of which it can be bolted to a similar pipe or seating.

Flanged Rail (*Eng.*) A rail with a flat flange at the bottom by which it is fastened down (*cf.* tramway rails); the ordinary form of rail now used on most kinds of permanent way is reversible, known as the DOUBLE HEADED RAIL, and has the same section at the top and bottom.

Flanged Seam (*Eng.*) A joint (made by two flanges) in a furnace tube, to allow of expansion and contraction during heating and cooling. The flanges are connected by a ring of wrought iron, often dished or corrugated.

Flanged Wheel (*Eng.*) A wheel with a flange round it, *e.g.* an ordinary locomotive or railway carriage wheel.

Flange Joint (*Eng., etc.*) Iron pipes having flanges at their ends for bolting together instead of spigot and socket.

Flanges on Cylinders (*Motor Cars, etc.*) Flanges are cast on the outside of the cylinders of small air cooled motors to increase the radiating surface and thereby aid in cooling the cylinder; they are usually termed RIBS *or* RADIATING RIBS.

Flanging (*Eng.*) The formation of a FLANGE (*q.v.*) by "up-setting" the end of a wrought iron tube by forging.

Flanks (*Build.*) The sides of a structure, especially of an arch (*q.v.*)

—— (*Eng.*) The lower part of the teeth of a spur wheel.

Flank Wall (*Build.*) A side wall.

Flannelette (*Textile Manufac.*) A fabric with a cotton warp and a woollen weft; also a fabric consisting entirely of cotton, both being made in imitation of woollen flannel.

Flap (*Carp.*) In general, a hinged board; *e.g.* the part of a counter that lifts up: a trap door.

Flap Trap (*Build.*) An iron flap on the sewer end of a drain.

Flap Valve (*Eng.*) A hinged valve; sometimes wholly or partly made of leather.

Flare Lard. A product obtained from the flare of a pig as opposed to the fat from the ham, breast, or back. It is characterised by the pronounced chisel shaped crystals of stearic acid which form on the evaporation of an ether solution, but which are scarcely distinguishable in soft lard.

Flare Lime (*Chem. Eng.*) Lime produced in a kiln out of contact with the solid fuel.

Flaser Structure (*Geol.*) A descriptive term applied to schistose rocks which were formerly massive, and have been sheared or drawn out by differential movements of the earth's crust during the earlier stages in the process of mountain making. The edges of the rock fragments thus sheared have a peculiar stringy look like the frayed out end of a cord. The structure may occur in rocks of any age, but is most commonly met with amongst those of great antiquity.

Flash Boiler (*Eng.*) A boiler in which water is instantaneously converted into steam by injection into tubes heated to a high temperature. Flash boilers are often used in steam motor cars, as they occupy little space. *See also* BOILERS.

Flashed Glass (*Dec.*) *See* GLASS MANUFACTURE and FLASHING (*infra*).

Flashing (*Build.*) Sheet lead or zinc, used to make a water-tight joint in the angle between a roof and a wall, or two parts of a roof meeting at an angle.

—— (*Glass Manufac.*) Casing or coating one glass with glass of a different colour.

Flashing Point *or* **Flash Point.** A term chiefly applied to mineral oils to indicate the temperature at which the oil, on being slowly heated, will give off inflammable vapour in sufficient quantity to "flash" or ignite on the application of a light. When the oil is further heated and continues burning, the temperature at which this commences is termed the "fire test." The methods employed for testing the flashing points of oils may be divided into two classes, *i.e.* the open test and the close test, which in this country are chiefly used for lubricating oils and illuminants respectively. In the former test the cup may be of any reasonable size, containing any convenient volume of oil, the "flash" being tested by passing a small jet of gas over the surface from time to time. In the latter the size of the cup, contents, rate of heating, size of gas jet, and frequency of testing for the "flash" are all precisely defined; and corrections have to be made for barometric pressure in relation to vapour tension. The standard instrument in this country is known as the ABEL CUP. Most countries have stringent laws as to the storage and sale of mineral oils based upon

what is considered the safe flashing point. In this country the Government minimum test for burning oils is 73° F. (*close test*), and applies essentially to imported oils, all the home production being well over 100° F. (Abel). The 73° F. standard is considerably lower than in most other countries, and efforts have frequently been made to raise it to 100° F. by legislation, but without success. The flashing point of other liquids besides mineral oil is sometimes of importance, as in the case of paints that are to be used in a confined space, such as a ship's cabin, where the accumulation of volatile materials given off by the special paints sometimes employed has given rise to serious accidents. Special official directions have recently been issued for testing such paints, metal polishes, etc.

Flask (*Chem., etc.*) A hollow vessel of thin glass, with a constriction or "neck" at the top. Flasks of many forms are very largely used in chemical and other experimental work.

—— (*Eng.*) The box in which sand is placed in the foundry to form a MOULD (*q.v.*) for the smaller sized castings. Flasks are made in two or more pieces which can be separated to enable the PATTERN (*q.v.*) to be withdrawn.

Flasques (*Her.*) A diminutive of FLANCHES; also called voiders.

Flat (*Build.*) A flat roof or part of a roof covered with lead, copper, or zinc.

—— (*Music*). A sign ♭ indicating that a note is to be lowered a semitone.

Flat Backs (*Bind.*) Whole bound or half bound books whose backs have the leather firmly glued or pasted to them. The style is nearly obsolete, except in the case of books subjected to great wear and tear, *e.g.* lending-library books. At present the leather is not usually connected to the back of the book; this prevents the back from creasing, and causes the book to open better.

Flat Joint (*Build.*) A mortar joint flush with the face of the wall.

—— **Jointed** (*Build.*) A flat joint with a groove made with a jointer (*q.v.*)

Flatness of Field (*Photo.*) A lens is said to give a flat field when the image of a distant object is equally in focus, whatever part of the screen it occupies. A small stop helps to correct want of flatness to a large extent.

Flatness of Image (*Photo.*) An image which is weak and wanting in vigour; usually an effect of over exposure or poor lighting.

Flats (*Eng.*) Iron bar of rectangular section, one side of the rectangle being considerably larger than the other. Still thinner bars are usually termed STRIP IRON.

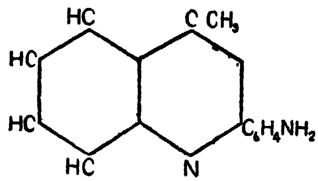
Flattener (*Glass Manufac.*) The workman whose duty it is to flatten cylinders into sheets. *See* GLASS MANUFACTURE.

Flatter (*Eng.*) A broad-faced tool used for producing flat surfaces in forging. It is held by a hammerlike handle and struck by a sledge hammer.

Flatting (*Dec.*) A method of finishing painted work without gloss. This is effected by omitting oil and thinning wholly with turpentine, a little varnish being added to bind the pigment together. As a rule the best results are obtained by using as a foundation a good glossy ground, and finishing with a coat of flatting.

Flaunching or **Flaunced Work** (*Build.*) The cement fillet round the bed of a chimney pot.

Flavaniline (*Chem.*)

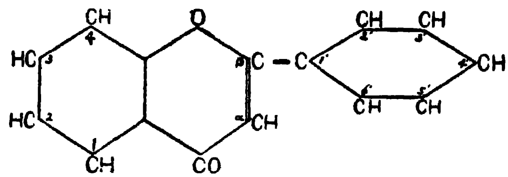


(α-para-amidophenyl-γ-methylquinoline). Colourless needles sparingly soluble in water, easily soluble in alcohol; melts at 97°. Obtained by heating acetanilide with zinc chloride, and by condensation of ortho- and para-amidoacetophenone. Its hydrochloride and its sulphonic acid were at one time used as greenish yellow dyes.

Flavanthrene. *See* DYES AND DYEING.

Flavine. *See* DYES AND DYEING.

Flavone (*Chem.*)

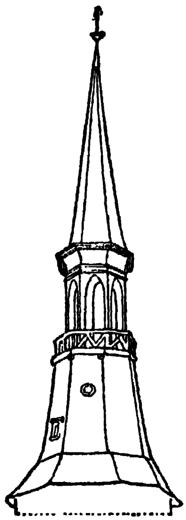


(β-phenyl-γ-benzopyrone). The stem or parent substance of a number of important naturally occurring substances, some of which are dyes. CHRYSIN is 1:3 dioxyflavone; forms *pale* yellow needles, and occurs in the buds of the poplar. APIGENIN is 1:3:4′ trioxyflavone, and occurs as a glucoside (apiin) in parsley and celery; it is also *pale* yellow. LUTEOLIN is 1:3:3′:4′ tetroxyflavone; is the colouring matter of Wald, an important beautiful yellow dyestuff. QUERCETIN is α:1:3:3′:4′ pentoxyflavone, and occurs as the glucoside quercitrin, which is found in the dye wood quercitrin bark, in tea, onions, horse chestnut, etc. It is a valuable yellow dye. FISETIN and MORIN are respectively α:3:3′:4′ tetroxyflavone and α:1:3:2′:4′ pentoxyflavone, and are the colouring matters of young fustic and old fustic.

Flavopurpurin. *See* DYES AND DYEING.

Flax. *Linum usitatissimum* (order, *Linaceæ*). The macerated bast fibres of the stem form the flax used in the manufacture of linen. The seeds are the well known LINSEED. The fibre of the flax plant has been used for manufacturing purposes since the time of the ancient Egyptians. From the botanical name "Linum" we get "lint" and "linen." The German name is "Flachs," and Dutch "Blasch." The fibrous portion is the inner bark, or rather lies between the bark and stem, surrounded by gummy matter, which is removed by "retting" (*q.v.*) *See* LINEN MANUFACTURE.

Flêche (*Architect.*) A wooden spire, usually situated on the ridge of a roof.



FLÊCHE.

Fled Ware (*Pot.*) Ware is described as fled when at any stage of its manufacture after the bisque firing it cracks spontaneously. This is generally caused by either too rapid heating or too rapid cooling at one or other of its burnings.

Fleece (*Woollen Manufac.*) A term applied to the wool when clipped from the sheep's back.

Fleece Wool (*Woollen Manufac.*) Wool grown subsequently to yearling.

Flemish Bond (*Build.*) Each course of bricks belonging to this class of bond consists of "headers" and "stretchers" placed alternately. Flemish Bond may either be single or double. In the former the wall is faced with bricks arranged in Flemish and backed with English bond, while in the latter both the facing and backing are Flemish.

Flemish School of Painting. *See* PAINTING, SCHOOLS OF.

Fleshing (*Leather Manufac.*) Removal of adhering flesh or fat from a skin previous to further treatment.

Flesh Side (*Eng.*) The side of a leather belt which formed the internal surface of the hide. This is the side which comes in contact with the pulley and driving wheel.

Flesh Split (*Leather Manufac.*) *See* BAG HIDES.

Fleur de Lis. The heraldic lily: a conventional flower emblem of France. The three lilies of France appeared on the Arms of England from 1299, when Edward I. married Margaret of Anjou, until 1801, when the union of Great Britain and Ireland took place.

Fleurettée *or* **Florettée** (*Her.*) Ending in fleur de lis.

Fleurie (*Her.*) Ending in three points.

Fleuss Pump. *See* AIR PUMPS.

Fleuss Tyre (*Cycle*). *See* TYRES.

Flexed (*Her.*) Curved or bowed.

Flexible (*Bind.*) Applied (*a*) to small Prayer books, Bibles, etc., sewn with silk to silk cords; and (*b*) to music, etc., bound without sewing, the backs of the leaves being cemented together with an india-rubber solution, thus ensuring good flat opening.

Flexible Coupling (*Eng.*) A coupling (*q.v.*) which enables two shafts not in the same straight line to be connected so as to turn together. It usually consists of a ball and socket joint; but a HOOKE'S JOINT (*q.v.*) is sometimes used.

Flexible Shafting. *See* SHAFTING, FLEXIBLE.

Flexible Tubing. *See* TUBING, FLEXIBLE.

Flexure *or* **Bending.** The bending of a beam is measured either by the deflection of a given point in it from a straight line, or by the curvature which it acquires under the action of the load.

Flier (*Joinery*). A step parallel in its width. *Cf.* BALANCED STEPS *and* DIMINISHED FLIER.

Flight (*Build.*) A number of consecutive steps between a floor and landing.

Flints (*Geol.*) Nodular concretionary masses of impure chalcedony, which represent what was formerly silica of organic origin dispersed throughout its matrix. The most familiar examples in Britain occur in the Chalks; but flints are of common occurrence in other limestones, even of Tertiary age. Much of the silica under notice was formerly part of the organic structure of sponges. The silica has been dissolved by percolating water, and redeposited around some organic nucleus at a lower level. It is frequently formed by replacement of its matrix.

Flint Ware (*Pot.*) The name applied in the United States to stone ware.

Flitch (*Eng., Build., etc.*) A piece of metal or wood fixed to a beam, etc., to add to its strength.

Flitch Beam *or* **Flitched Beam** (*Eng., Build., etc.*) A wooden beam built up round a core, plate, or central piece of wrought iron, the whole being held together by bolts. *See also* FLOORS.

Flitch Plate (*Eng., Build., etc.*) A flitch (*q.v.*)

Float (*Eng., etc.*) A floating object (wood or a thin hollow vessel of metal) which is used to indicate the level of water, etc., in a boiler or tank. It usually actuates some form of dial or pointer, on which divisions representing the level of the liquid are marked.

—— (*Motor Cars*). A hollow vessel, usually of thin sheet metal, which floats on the surface of the motor spirit in one of the chambers of a carburetter (*q.v.*), and by rising and falling with the variations in depth of the spirit, acts on a valve and controls the supply. *See also* SPRAY CARBURETTER.

—— (*Plast.*) A flat rectangular plate of steel, with a handle fixed on one side, used for smoothing flat surfaces of plaster.

—— (*Textile Manufac.*) A defect in weaving which gives an irregular appearance to the cloth. Also a term used in designing to denote the number of ends or picks a thread passes over, *i.e.* four pick float, etc.

—— *or* **Float Cut File** (*Eng.*) A file with only one series of teeth, which do not cross, as in the ordinary file. *See* FILE.

Floated (*Build.*) The surface of plaster which has been finished with a float.

Floating Bridges (*Civil Eng.*) Bridges carried by boats or pontoons (*q.v.*), used for temporary purposes, or in cases where openings have to be made for the passage of vessels, or where a good foundation cannot be obtained. One of the best examples is at Calcutta; this bridge is 1,530 ft. long and 48 ft. wide, and is carried on twenty-eight iron pontoons. The bed of the river Hugli is so loose and the current so rapid that permanent foundations are not practicable in this case.

Floating Card Compass. A magnetic needle to which is fixed a card, which turns with the needle. The card is divided into degrees; a line on the card marked N and S points due north, *i.e.* makes an angle with the needle equal to the magnetic declination (*q.v.*) at the place where the compass is to

be used. Thus, instead of reading the deflection of the needle relative to the card, as in an ordinary compass, the deflection of the card relative to a fixed mark on the inside of the case of the instrument is read.

Floating Mill Wheel. An undershot wheel carried by a boat or raft and actuated by the current of a river in which it is moored: a contrivance not often used.

Floating Reef (*Mining*). Loose masses of ore disconnected from the principal vein.

Floating Vessel (*Glass Manufac.*) This is made of fireclay, and consists of two or three compartments. Used in tank furnaces for refining the metal. The molten glass enters at a depth below the surface of the metal in the tank, and is withdrawn therefrom by the gatherer.

Floats *or* **Float Boards** (*Eng.*) The vanes or paddles of a paddle wheel or undershot (*q.v.*) water wheel.

Float Stone (*Min.*) A porous variety of silica containing so much air that a piece will float on water. Found near Paris.

Flock Paper (*Dec.*) A wallpaper with a raised surface, formed by printing the pattern with gum or other adhesive material and dusting on fine shreds of plain or coloured wool. In "silk flocks" the wool is replaced by silk shreds. Flock papers are not now used to any considerable extent.

Flogging (*Eng.*, *Carp.*, *etc.*) A term for the removal of the rough surface or of large pieces of wood, metal, etc., while the piece of material is being cut approximately to shape.

Flogging Chisel (*Eng.*) A large cold chisel occasionally used in heavy cutting.

Flong (*Stereotyping*). Flong is used in the *papier-maché* process of stereotyping. It is composed of a number of layers of tissue and blotting papers used alternately, with paste or composition between. In a plastic state it is placed upon the form, and its surface beaten until an impress of the face of the type is obtained. When hardened, it becomes the mould from which a stereotype plate is produced.

Flood (*Meteorol.*) Owing to excessive rainfall, rivers, lakes, ponds cannot be restricted to their banks, and the overflowing of the water causes floods in the regions around.

Flookan *or* **Flucan** (*Mining*). A vein containing a great deal of clay.

Floor (*Foundry*). The sand bed which forms the floor of a foundry; it serves as a reservoir of rough sand, and also as the receptacle for large moulds in making heavy castings.

Floor Cramp. A cramp for squeezing floor boards together whilst being nailed.

Floors. The simplest kind of floor is that known as a SINGLE FLOOR (fig. 1). This is used in cases where the span is not more than 15 or 16 ft. It consists of a number of COMMON or BRIDGING JOISTS AAA, whose ends rest on a WALL PLATE B, which rests either on an OFFSET or ledge as shown, or on corbels (*q.v.*) specially built to carry it. On the top of the joists are nailed the FLOOR BOARDS CCC. The joists are usually from 8 to 11 in. deep, and are set about 1 ft. apart. The laths which carry the ceiling below the floor are either nailed to the joists or else to small CEILING JOISTS DD. When the span is large, common joists would not be sufficiently strong to be used alone; in this case heavier timbers are used to support the ends of the common

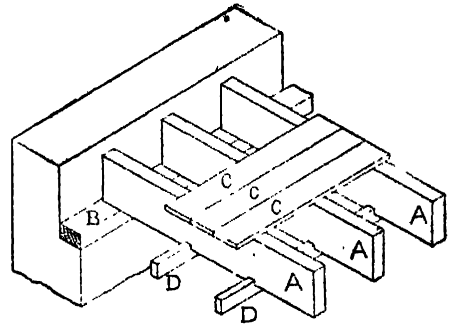


FIG. 1.—SINGLE FLOOR.

joists at convenient positions: the combination is then termed a DOUBLE FLOOR (fig. 2). The joists AA rest on the larger timbers or BINDERS, one of which is shown at EE. The binder may be notched, as shown at F, or the notch may be made in the joist only, which is the preferable method, as it does not

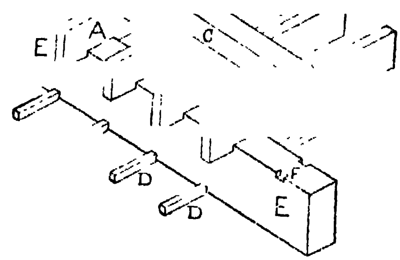


FIG. 2.—DOUBLE FLOOR.

weaken the binder. A double floor usually has ceiling joists DD, which are often fixed to the binders by means of a CHASE MORTICE, a mortice into which the tenon can be inserted by sliding it along a groove or CHASE. For very large spans a double floor is superseded by a DOUBLE FRAMED FLOOR (fig. 3 and

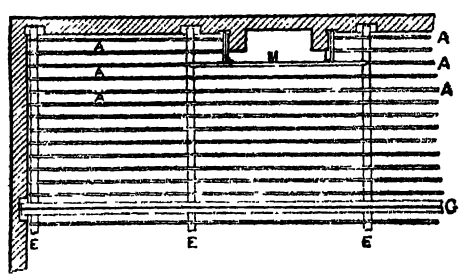


FIG. 3.—DOUBLE FRAMED FLOOR.

fig. 4). AAA are common joists resting on binders EEE: The binders are supported by a GIRDER G. In fig. 4 is shown a cross section of a FLITCH GIRDER, consisting of two half-timbers HH placed with the

heart-wood outwards and strengthened by an iron plate K, termed a FLITCH PLATE, the whole being secured by bolts which fasten the timbers and iron plate together. The binders may be morticed into the girder by means of a TUSK TENON (*q.v.*), or may be supported by an iron stirrup or bracket which rests on the girder. The latter method is preferable, as the strength of the girder is not diminished by cutting a mortice in the material. When an opening has to be made in a floor, *e.g.* round a staircase or fireplace, the joists are TRIMMED, *i.e.* supported by

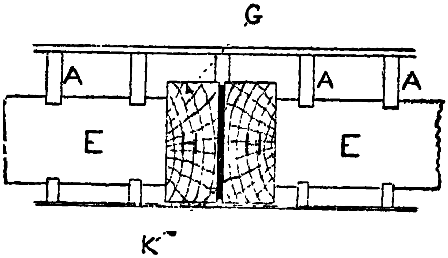


FIG. 4.—DOUBLE FRAMED FLOOR

intermediate timbers, as shown in fig. 3. These timbers or TRIMMERS are shown at LL. The joist M is termed a TRIMMING JOIST, and is made of greater thickness than the common joists, in order to enable it to carry the extra load thrown upon it. In fig. 3 it will be seen that the ends of binders and girders alike are carried in openings or POCKETS in the wall, and are not built in. The timber rests on a stone base or template, and the top of the pocket or opening may be formed by a single stone or by a small arch, so as to allow a free play of air round the end of the timber.

Floor Space (*Hygiene*). To deal effectually with the problem of maintaining the air of rooms in a pure condition, an adequate allowance of floor space is essential. At the lowest it should not be less than one-twelfth of the cubic space. Set out below will be found a minimum floor space for different institutions:

Tents and vans .	16	sq. ft.	for each adult male.
Schools . . .	10	,,	per scholar (elder).
,, ...	8	,,	,, (infant).
Artizans' dwellings	150	,,	in living room.
,, ,,	120	,,	,, bedroom (adults).
,, ,,	80	,,	,, ,, (children).
Hospitals . .	120	,,	per bed.

It is of great importance that a good floor space should be provided per bed in hospitals, to ensure a supply of pure air, and for facilities for nursing.

Floran (*Mining*). Fine tin ore.

Florentine Mosaic. Mosaic work formed by inlaying small surfaces of marble with precious stones, such as chalcedony, etc.

Florentine School of Painting. *See* PAINTING, SCHOOLS OF.

Florid Gothic (*Architect.*) *See* PERPENDICULAR *and* TUDOR.

Flos Ferri (*Min.*) A variety of aragonite (*q.v.*) occurring in coralloidal masses, usually of a white or faint brown colour. The name is derived from its association with iron (in the mines of Styria). Other localities are Silvera Band Mine, near Milburn, and Rundale Mines, near Dufton, in Westmoreland, and the mines of Wanlockhead, in Dumfriesshire.

Flour (*Foods*). The term flour, without any modification, generally means wheat flour. This is divided into two groups—white wheat and dark wheat. The colour in the latter case is due to the presence of bran. A good flour should be quite white, and not gritty or lumpy. It should not taste acid, although when tested with paper (litmus) the reaction should be slightly acid. Flour is adulterated by (*a*) the flour of other grains and (*b*) mineral substances. In the first section we have barley, maize, peas, rice, oats, etc.; and in the second, alum, gypsum, carbonate of magnesia, carbonate of calcium, etc. Detection of these adulterants is obtained by microscopic and chemical examination. *See also* BREAD.

Flouring (*Met.*) The spoiling of the mercury used in gold extraction by absorption of impurities from the ore.

Flow *or* **Flow Pipe.** The pipe by which the water leaves a boiler. Used to heat a building, etc.

Flowers of Sulphur. Finely divided sulphur, obtained by sublimation (*q.v.*)

Flowing Tracery (*Architect.*) *See* CURVILINEAR *and* DECORATED.

Flue (*Eng.*, *Build.*, *etc.*) A general term for a passage through which smoke, etc., escape from a furnace or fire. In boilers the flues are commonly utilised as part of the heating surface. *See* BOILERS.

Flue Bridge (*Eng.*) A barrier of firebrick placed so as to deflect the flames and hot gases in a furnace.

Flue Work (*Music*). All organ stops not belonging to the Reed family. Flue work is subdivided into: (1) Principal work, (2) Flute work, (3) Gedact work.

Fluffing (*Leather Manufac.*) The process of rubbing the skin on a revolving emery wheel to fluff it, *i.e.* make it smooth.

Fluffy (*Carp.*) Timber which cuts up in a "stringy" manner.

Fluid. A fluid is a substance which is unable to resist the action of any force (however small) which tends to change its shape. *See* LIQUID *and* GAS.

Fluidity. The property of flowing easily and readily: the opposite of viscosity.

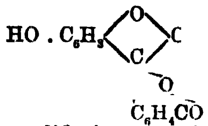
Fluid Ounce. *See* WEIGHTS AND MEASURES.

Fluke (*Mining*). A rod used to clear out holes which have been drilled to receive a charge for blasting.

Flume (*Eng.*, *Mining*, *etc.*) A channel (usually open at the top) for carrying water, *e.g.* to a mill-wheel, etc.

Fluorene (*Chem.*) $\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}\!\!\Big> CH_2$ (diphenylenemethane). Colourless needles showing a violet fluorescence; melts at 113° C. It occurs in that fraction of coal tar which distils from 300 to 305° C. It is formed by passing the vapour of diphenylmethane through a redhot tube. BIFLUORENE (bidiphenylene ethylene) $\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}\!\!\Big> C : C \Big<\!\!\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}$, formed when fluorene is heated with bromine, is remarkable as being a

coloured hydrocarbon; it crystallises in beautiful red needles.

Fluorescein (*Chem.*) 

Dark yellow crystalline solid; insoluble in water; soluble in glacial acetic acid. Obtained by heating resorcin (*q.v.*) with phthalic anhydride (*q.v.*), alone or with sulphuric acid or zinc chloride. It dissolves readily in alkalis, forming a salt, and the solution has a yellowish brown colour, with a magnificent green fluorescence. It is used as a dye. *See* EOSIN *and* ERYTHROSIN.

Fluorescence. A number of substances, when illuminated by light of certain wave length, emit light of greater wave length (and therefore of different colour). This property is termed FLUORESCENCE, and is possessed by fluorspar (from which the name is derived), certain organic compounds, *e.g.* eosin, quinine, fluorescein, and also by a number of salts.

Fluorides (*Chem.*) Salts of HYDROFLUORIC ACID (*q.v.*)

Fluorine, F. *Atomic weight*, 19. A gas similar to, but lighter in colour than, chlorine. Has a powerful and irritating odour; is liquefied about $-185°$, forming a yellowish liquid. It is obtained by electrolysis of hydrofluoric acid, to which a little potassium hydrogen fluoride has been added. Platinum or copper vessels must be used throughout. *It is the most reactive element known.* Unites with hydrogen with explosion. Most other elements burn in it, forming fluorides; but oxygen and nitrogen do not combine with it. Glass is instantly decomposed by it. Silica becomes redhot in it, and organic compounds are immediately decomposed. In all cases fluorides are formed. Liquid fluorine is less active; it does not attack glass. Gaseous fluorine passed into liquid oxygen forms a white flocculent precipitate, which deflagrates violently when its temperature rises.

Fluorspar (*Min.*) Calcium fluoride, CaF_2. Calcium = 51·3, fluorine = 48·7 per cent. Cubic; in crystals of a great diversity of colour, most commonly blue, green, or yellow. It exhibits fluorescence and phosphorescence when heated. With sulphuric acid gives off fumes of hydrofluoric acid, in the manufacture of which it is used. Sometimes used as a flux. The massive varieties are used as ornamental stones. From Alston Moor, Derbyshire, Cornwall, the Harz, Bohemia, many parts of North America, etc.

Flush (*Eng.*) At the same level; forming part of the same surface.

—— (*Hygiene*). The water that flushes out a closet pan, etc.

Flushing (*Eng., etc.*) Clearing out a space by passing a quantity of water or air through it. Drains are flushed by clean water. A gas engine cylinder is sometimes flushed or cleared of the products of combustion by driving a quantity of pure air through it. The valves of automobile motors are "flushed" with spirit to wash grit or deposit from the seatings.

Flush Joint (*Build.*) *See* FLAT JOINT.

Flush Panel (*Carp.*) A panel that is level with the framing; *i.e.* one whose surface lies in the same plane as that of the framing.

Flush Tanks, Automatic (*Hygiene*). It is not always possible to give the sewers and drains sufficient fall to make them self-cleansing. Under these circumstances the normal flow of sewage should be supplemented by automatic flush tanks. They should be placed at the head of the drain, and made to discharge at whatever intervals are found necessary. Of the many forms on the market, Field's flush tank (*q.v.*) takes the highest place. The use of these tanks is also of considerable value in schools, public buildings, and châlets.

Flute. *See* MUSICAL INSTRUMENTS: WIND (WOOD).

Flutes (*Architect.*) The vertical hollows formed in the shafts of classical columns and pilasters, either with or without fillets. *See* ARCHITECTURE, ORDERS OF; CABLE.

—— (*Carp.*) The cylindrical sinkings cut in a column, bracket, or pilaster.

—— (*Glass Manufac.*) The furrows in rolled plate glass.

Flute Work (*Music*). The flue stops of an organ not belonging to the principal or gedact work.

Fluting (*Eng., etc.*) Parallel grooves, of any form of cross section, in an object. They may be merely ornamental or may serve some useful purpose, as in a REAMER (*q.v.*), in which they often form cutting edges.

Flux (*Elect.*) The total number of lines of force which pass through any given space or cross any given area.

—— (*Met., Chem.*) A substance used to facilitate the fusion and subsequent separation of impurities in metallurgical and soldering operations. Thus in the blast furnace, when clay ironstone is the ore, limestone is added to form a fusible slag of a double calcium and aluminium silicate which is easily separated from the iron. In welding iron, sand, which is an easily fusible silicate of iron, is used as a flux to remove the oxide of iron; in brazing, borax is used as a flux because it easily dissolves metallic oxides. Resin, sal-ammonia, and "killed spirits" (zinc chloride) are used in soldering. BLACK FLUX, often used in blowpipe operations, is a mixture of potassium carbonate and carbon.

—— (*Pottery*). A material composed of agents that will melt at a comparatively low temperature, such as alkaline salts, in combination with silica, lime, or lead. It is used in the formation of glazes and enamel colours. In the form of lime it gives translucency to porcelain.

Flux Density (*Elect.*) The FLUX (*q.v.*) per unit area, *i.e.* the number of lines of force which pass through a unit area placed at right angles to the lines.

Fly (*Clocks*). A fan used to control the speed of a running train of wheels, as in the striking trains of a clock. It is usually a rectangular sheet of thin metal, fitted spring tight on its pinion in house clocks, or with a ratchet and click in turret clocks, so that it may continue to move until its energy is expended and without injury to the mechanism of the clock, after the pinion has been arrested and the train locked. *See* RATCHET *and* TRAIN.

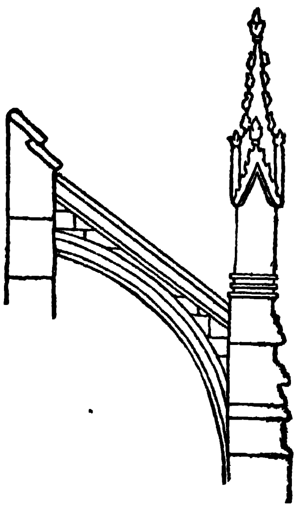
Fly (*Woollen Manufac.*) The fibre given off various rollers in carding (*q.v.*); also applied to the FANCY (*q.v.*)

Fly Batten (*Silk Manufac.*) *See* BATTEN.

Fly Cutters (*Eng.*) Revolving cutting wheels, such as are used in a milling machine, for shaping small objects to a special form.

Fly Frames (*Cotton Manufac.*) A general term applied to slubbing, intermediate, roving, and jack frames. Sometimes also termed speed frames.

Flying Buttress (*Architect.*) A form of buttress frequently used in Gothic churches to take the thrust of the nave vault. It consists of a vertical buttress placed on the external wall of the aisle and connected to the nave wall by means of an arch.



FLYING BUTTRESS, SALISBURY CATHEDRAL.

Flying Shore (*Build.*) A horizontal shore.

Fly Leaf (*Bind.*) *See* END PAPERS.

Fly Nut (*Eng., etc.*) A nut with wings to enable it to be turned by thumb and fingers.

Fly of a Flag. The length that it extends from the staff measured along the edge. The measurement along the edge parallel to the staff is termed the "Dip."

Fly Press (*Eng.. etc.*) A press in which a die is driven by a screw working vertically through a fixed nut, the screw carrying heavy loaded arms.

Fly Shuttle (*Textile Manufac.*) The method of picking (*q.v.*) invented by John Kay.

Flywheel (*Eng.*) A heavy rotating wheel. It serves as a store of energy, and helps to maintain a steady rate of rotation of the shaft of the engine or other machinery to which it belongs. The size of a flywheel, or more exactly its MOMENT OF INERTIA (*q.v.*), is determined by the normal speed of the engine and by the fluctuations of speed which are permissible. An engine which is required to run very steadily, *i.e.* with very small fluctuations of speed, as in the case of an engine driving a dynamo, requires a heavier flywheel than one where variations in speed are of small importance.

F.O.B. Free on board: applied to goods which the seller undertakes to deliver on board ship without any charge for carriage or loading.

Focal Length of a Lens (*Phys.*) The true focal length of a lens is the distance from the principal focus (*q.v.*) to the nearest principal point (*q.v.*) In the case of a thin lens it is sufficiently accurate to measure the distance from the surface of the lens itself to the principal focus.

Focal Planes of a Lens (*Phys.*) A pair of planes drawn through the PRINCIPAL FOCI (*q.v.*) of a lens at right angles to the axis.

Focus (*Phys.*) The point towards which rays converge or from which they appear to diverge.

——, **Principal** (*Phys.*) A pencil of parallel rays of light after incidence on a mirror or lens is caused to converge towards a single point or to appear to diverge from a single point. This point is called the PRINCIPAL FOCUS of the mirror or lens. In the second case the principal focus is VIRTUAL, in the first case it is REAL.

Focussing. The adjustment of the position of certain parts of an optical instrument, *e.g.* the eyepiece of a telescope or microscope, or the lens of a camera or lantern, in order to obtain a clearly defined image.

Focussing Lens (*Lantern*). In lantern work the objective is often so termed. *See* LANTERN OBJECTIVE.

—— (*Photo.*) A magnifying glass by means of which the image on the ground glass screen of a camera is examined, in order to obtain the most exact position in focussing.

Foehn Winds (*Meteorol.*) The name for warm, dry winds or hot waves peculiar to some mountainous regions, as the Alps in Switzerland.

Fog (*Photo.*) A general name for a darkening of parts of an image, usually through the improper action of light; occasionally "chemical fog" is produced by some fault in the composition of the solutions used. *See* GREEN FOG, RED FOG, GENERAL FOG.

—— (*Meteorol.*) When air is cooled just below dew point, then fog, mist, or cloud occurs. Dust particles in the air accelerate the formation of fog; hence the frequency of fogs in large cities due to the small particles in smoke.

Fogbow (*Meteorol.*) A colourless or "white" rainbow occasionally formed on a mass of thick fog.

Fog Image (*Meteorol.*) The shadow of an observer cast on a fog or cloud bank by the sun.

Foils (*Architect.*) The leaf shaped spaces between the cusps used in Gothic tracery. *See* CUSP, TREFOIL, QUATREFOIL, CINQUEFOIL, *and* MULTIFOIL.

Fold (*Woollen Manufac.*) The term applied to yarns composed of two or more threads.

Folded Yarns (*Cotton Manufac.*) *See* DOUBLING.

Folding Doors (*Joinery*). A pair of doors with rabbeted (rebated) meeting styles.

Foliated Structure (*Geol.*) Rocks which have been sheared under great pressure deep within the Earth's crust during the earlier stages of mountain making nearly always show a banded arrangement of their constituents. Thus bands of felspar may alternate with others of mica, hornblende, or other minerals, and impart to the rock a pseudo-stratified appearance, which needs to be distinguished in some way. All gneisses and most schists are foliated rocks. The structure is due, in some cases, to chemical changes which have taken place during the shearing process.

Folklore Weather (*Meteorol.*) A saying with reference to approaching weather as foreshadowed by certain atmospheric conditions on objects animate and inanimate.

Follicle (*Botany*). A dry dehiscent fruit resembling the pod, but opening on one side only. Aggregations of these fruits are seen in the columbine, monkshood, etc.

Follicle (*Zool.*) A small saclike cavity or receptacle; *e.g.* the small pit in which the root of a hair is contained, or the structure which surrounds an OVUM (*q.v.*)

Follower (*Eng.*) A toothed wheel which is driven by another wheel, termed the DRIVER.

Fontainebleau Limestone (*Geol.*) A variety of calcite containing a large admixture of sand. From Fontainebleau in France. The percentage of sand may be as high as 80 per cent.

Food, Adulteration of (*Hygiene*). *See* ADULTERATION OF FOOD.

Foods (*Hygiene*). All food constituents may be classified as (1) nitrogenous, (2) fats, (3) carbohydrates, (4) salts, (5) water. (1) Nitrogenous foods include the albumens, and are necessary for the nutrition and repair of the tissues. Urea and uric acid produced in the system from nitrogenous foods are eliminated by the kidneys. When these are taken in excess it leads to a gouty condition. If too little nitrogenous food is taken, debility and loss of energy is produced. (2 and 3) Fats and carbohydrates, or starches and sugar, are necessary for the production of force and heat, and are eliminated from the body as CO_2 and water. The amount of these taken should depend on the amount of work done. If a large amount of muscular exercise is taken, there is a correspondingly great increase in the elimination of CO_2 and water. The starches and sugars are more easily eliminated than fats, but have not the same nutritive value. (4) The salts required for growth and nutrition are lime, potash, soda, and small quantities of iron. Phosphates, chlorides, and the nitrates and citrates of organic acids are also necessary. (5) Water in considerable quantity is also required, as it is contained in all the tissues of which the body is composed. The amount of nitrogenous food, fat, carbohydrates, and salts necessary per diem for an average man varies according to the amount of work done, but the following table (according to Whitlegge) may be given as a guide:

	Nitrogenous.	Fat.	Carbohydrates.	Salts.	Containing	
					Nitrogen.	Carbon
Rest . .	3 oz.	1½ oz.		1 oz.	200 gr.	4,000 gr.
Moderate work .	4½ ,,	[illegible] ,,	[illegible]		300	5,000 ,,
Hard work	6 ,,	4½ ,,	18		400	6,000 ,,

The following figures may be taken as the average of the above, and can be remembered readily: Nitrogenous, 5 oz.; fat, 3 oz.; carbohydrates, 15 oz.; and salts, 1 oz.; containing 350 gr. nitrogen and 5,000 gr. carbon. The above amounts are calculated free from water, and as most foods contain water, the actual weight in food stuffs will be nearly 50 oz. To this has to be added a further 40 to 50 oz. of water, which is necessary for digestion and assimilation of the food, as well as for the removal of effete products. Tables have been constructed showing the amount of water, albumen, fats, carbohydrates, and salts occurring in the chief articles of diet, and from these, by simple equations, the amount of each article of food necessary can be readily calculated. For example, how much bread, butter, and milk will be required to make up the average amount of albumen, fat, and carbohydrates? Bread contains 8 per cent. of albumen and 50 per cent. of carbohydrates; milk contains 4 per cent. albumen, 3 per cent. fat, and 4·5 per cent. carbohydrates; and butter contains about 80 per cent. pure fat. Let x be the amount of bread, y the amount of milk, and z the amount of butter required, then

$$\frac{8x + 4y}{100} = 5, \quad \frac{3y + 80z}{100} = 3, \quad \frac{50x + 5y}{100} = 15.$$

Working out these equations, we find that the amount of bread required is about 22 oz.; butter, ·7 of an oz.; and milk, 81 oz. A more complete dietary can be worked in the same way if the percentage composition of the foods selected be known. The quantity of food, and consequently the amount of the proximate constituents will necessarily vary according to the age, sex, and the work at which the individual is engaged. Besides being sufficient in amount, there must be a certain variety in the food taken. It must also be palatable, and for this purpose the various condiments are necessary. The food must likewise be of good quality, and the legislature has given powers to local authorities in the Public Health Acts to see that all foods exposed for sale or deposited in any place for the purpose of sale are fit for human food. Cattle are subject to certain specific diseases which render their flesh not only unfit for food, but also dangerous. The chief diseases are pleuropneumonia, cattle plague, anthrax, foot and mouth disease, glanders, farcy, and tuberculosis; in pigs, hog cholera, measles, trichinosis; and in sheep, rot due to the presence of small animals called "flukes" in the bile ducts of the liver. Good beef should be firm to the touch, of bright red colour, with a moderate amount of juice, and the fat should be white and hard. There should be no odour, and to test this a skewer can be thrust into the meat and smelt after being withdrawn. If there is any disagreeable smell, the meat should not be used, as this shows that putrefaction is commencing. The flesh of poultry should be whitish pink and firm, and the smell fresh. A slight bluish discolouration over the breast bone shows that the fowl has not been recently killed, but the flesh is not on that account unwholesome. If, however, on opening the bird, the smell is offensive, the flesh should not be eaten. With regard to game, this is not usually eaten till it is "high," this meaning that some decomposition has set in. Fish should be firm to the touch, and the smell should be fresh. Decomposition sets in very quickly in fish, and any staleness can be readily detected on opening them. Tinned meat is, as a rule, wholesome; but sometimes it may give rise to serious symptoms of poisoning due to the production of alkaloids called ptomaines. These may be produced in meat, pork, ham, or sausages, and it is frequently impossible to tell whether there are any present by simply looking at the articles. Sometimes, however, in the case of tinned foods, the tin is what is called "blown"; that is, the sides are blown out instead of being sunk in, this being due to putrefactive changes. Poisoning may take place also if the meat has absorbed any of the lead or tin, and this holds good also of tinned fruits. Bread is, as a rule, of very good quality, and the adulteration with alum which used to be practised has been given up. The only adulterant now employed, if it can be so called, is potatoes. If no bran is used, then the bread should be white in colour, and it should be free from acidity. *See* BREAD. Milk should be opaque and *fine white in colour*, and should on analysis give at least 3 per cent. of fat, 8·5 per cent. of solids not fat, and have a specific gravity of about 1,030. There should be no deposits either before or after boiling. As milk is the principal food of infants and young children, great care should be taken in regard to it. For

young children the milk should at once be boiled when delivered, and then placed in a thoroughly clean bottle or other closed receptacle in a cool place. If placed in large bowls, these ought to be covered so as to prevent contamination by means of flies or dust. No article of food is so susceptible of contamination, and if greater care were taken in the preservation and storage of milk in our houses there would be a great diminution in the infantile mortality from diseases of the digestive organs. *Preservatives should never be added to milk.* Nevertheless, occasionally salicylic acid, formalin, or boric acid are added by vendors to prevent it from turning sour. The souring of milk is due to the conversion of the sugar into lactic acid, which latter coagulates the casein, causing the milk to curdle. Colouring matter—*e.g.* annatto—is used to give it a richer colour, but this, though not injurious, is quite unnecessary. Water is the most common adulterant, but recently separated milk, or milk cleared of all its fat, is added, seriously affecting the nutritive value. Butter is a very commonly used food. It differs from margarine in that it is derived from milk, while margarine is derived from the fat of animals. There is little or no difference in the nutritive value, but butter fat is more readily assimilated. Tea is not at present adulterated, but coffee is frequently adulterated with chicory.

Foot. *See* WEIGHTS AND MEASURES.

Foot Block (*Carp.*) The flat piece of timber at the foot of a raking shore. *See* SHORES.

Foot Blower (*Glass Manufac.*) The glassmaker who gathers the metal and also makes the feet for wine glasses, etc. The third man in a set or "chair" of workmen (flint glass trade).

Foot Brake (*Motor Cars, etc.*) A brake applied by a lever or treadle which the driver actuates with his foot.

Footings (*Build.*) The projecting courses at the bottom of a wall.

Foot Pound (*Eng., Phys., etc.*) The English engineer's unit of work; the amount of work required to be expended in order to raise 1 lb. through a vertical height of 1 ft.

Foot Rests (*Cycles*). Small brackets on the front forks; rarely employed in ordinary cycles now that free wheels are usually fitted. In motor cycles foot rests are commonly fitted in a convenient position near the pedals.

Foots. A general term applied to the impure residue left in refining oils, fats, waxes and greases, such as cotton and linseed oils, spermaceti, Yorkshire grease. They are usually of very complex composition. Linseed oil foots contain a quantity of mucilage mixed with the oil, and are often used in making putty (*q.v.*) Cotton oil and grease foots are worked up in soap making.

Footstep Bearing (*Eng.*) A bearing (*q.v.*) which supports the lower end of a vertical shaft.

Foot Ton. The amount of work necessary to raise 1 ton 1 ft. high; it is equal to 2,240 ft. lbs.

Foot Valve (*Eng., etc.*) The valve at the bottom of a pump barrel or at the bottom of the suction pipe.

Footwall (*Mining*). The under or lower side of a vein or lode.

Footway (*Mining*). Ladders leading down a shaft, by means of which an ascent or descent may be made when the winding gear is not in operation.

F.O.R. Free on rail. *Cf.* F.O.B.

Foramen Magnum (*Zool.*) The large opening at the back of the skull through which passes the MEDULLA OBLONGATA (*q.v.*) of the central nervous system.

Foraminifera (*Zool.*) One of the divisions of the *Protozoa* (the simplest animals). The foraminifera possess a shell which is usually calcareous (composed of salts of calcium). The majority are marine, and are found at all depths. Their shells occur as fossils in rocks from Silurian age onward, and form the bulk of most kinds of chalk.

Force (*Phys., Mech., etc.*) Force is that which changes (or tends to change) the state of rest or motion of a body. It is also defined as "that which moves (or tends to move) matter."

Forced Draught (*Eng.*) An air supply driven through the fires of a boiler, etc., by means of fans or pumps, but principally by steam injectors, instead of the natural air current which is produced by the rush of hot air up the chimney or funnel. It is used when the boilers are being worked at a high power, *i.e.* when they are required to produce more than the usual amount of steam, as in the case of ships which are running at their highest possible speed.

Forced Draught Furnace (*Eng.*) The forced draught furnace, by which air and steam are supplied under pressure from steam jet injectors into a closed grate, has been very widely applied in late years to the combustion of inferior fuels (such as duff, breeze, pond, settlings, and washery refuse) and town's refuse, for the generation of steam and electric power. This system has almost revolutionised the working of destructors and assisted many manufacturing operations by obtaining steam power from waste products.

Forced Vibrations (*Phys.*) Vibrations produced in a body (or system of bodies) by a force periodically applied at intervals of time, which are not the same as the period of the natural vibrations. Thus a pendulum may be made to execute forced vibrations if it be struck intermittently, or if the point of suspension be moved to and fro at intervals different from the natural period of the pendulum.

Force, Lines of (*Elect.*) *See* LINES OF FORCE.

——, Moment of (*Phys.*) *See* MOMENT OF FORCE.

Force Piece (*Mining*). Diagonal struts across a working.

Force Pump (*Eng.*) A pump in which the water is driven upwards by the pressure of a solid piston (*i.e.* one without valves). The height to which the water can be raised is independent of atmospheric pressure (which limits the height reached in the suction pump), and depends only on the power applied and the strength of the pump and pipes. *See also* PUMPS.

—— (*Plumb. and Gas Fitting*). An air pump for cleaning out service pipes.

Forces, Composition of (*Mech.*) The calculation of the RESULTANT (*q.v.*) of two or more forces.

——, Moment of (*Mech.*) The moment of a force about a given point is the product of the amount of

the force into its perpendicular distance from the point.

Forces, Parallelogram of (*Mech.*) If two forces acting at a point be represented in magnitude and direction by the sides of a parallelogram, then the RESULTANT (*q.v.*) of the two forces is similarly represented by the diagonal of the parallelogram.

——, **Polygon of.** Any number of forces in equilibrium, acting at a point, may be represented in magnitude and direction by the sides of a completely closed polygon, taken in order. *See also* GRAPHIC STATICS.

——, **Resolution of** (*Mech.*) Any force may in general be replaced by two or more forces, which, when acting together, produce the same effect as the original force. The process of calculating the "components" of a force is termed the resolution of the force.

——, **Triangle of** (*Mech.*) If three forces acting at a point be in equilibrium, they may be represented in magnitude and direction by the sides of a triangle, taken in order. *See also* GRAPHIC STATICS.

Force, Tubes of (*Elect.*) *See* TUBES OF FORCE.

Fore Carriage (*Eng.*) The frame carrying the front wheels of a traction engine or locomotive.

—— (*Cycles, etc.*) A light two-wheeled carriage fixed in front of a motor bicycle. The front wheel of the latter is removed, and the forks are connected to levers which act upon the axle of the fore carriage, which is of the Ackerman (*q.v.*) or some similar form. The cycle is thus converted into a light three wheeled car.

Forecasts (*Meteorol.*) A prediction of the probable state of the weather a short time ahead; based chiefly on changes of barometer pressure, etc., which are actually known to be spreading or progressing in a definite direction.

Foredge (*Binding*). The front edge of a book, the edge opposite to the back.

Foreground (*Paint.*) The part of a picture on which objects intended to be nearest the eye of the spectator are presented.

Fore Observation (*Surveying*). The opposite of back observation (*q.v.*)

Foreplate (*Met.*) A guide and resting plate in front of the bottom roll of the finishing grooves or rolls of a forge train (*q.v.*)

Foreshortening (*Paint., etc.*) A method of representing objects or figures, or portions of objects or figures, which lie in a direction not parallel to the plane of a picture, bas-relief, or a piece of sculpture, in order to present the object as it appears to the eye.

Forest Beds (*Geol.*) Strictly speaking, the word "forest" means simply a place outside the limits of cultivation, and has nothing to do with trees. But the term has come to be employed in the sense of extensive wooded areas. Certain strata are found to contain the stumps of trees, apparently in the position of growth. These have been somewhat fancifully described as forest beds. The Forest Bed of East Anglia is part of an ancient delta of the Rhine, and contains many remains of tree fragments along with other organic remains. It is of late Pleiocene Age.

Forest Marble (*Geol.*) A member of the Middle Oolites, which is abundantly fossiliferous in the southern parts of the kingdom. It comprises beds of clay and sandstone, together with a bed of oolitic limestone, which has occasionally been polished and used as marble.

Forge (*Eng.*) (1) A blacksmith's hearth, with its accessories. (2) A blacksmith's shop.

—— (*Met.*) In iron works the department in which the puddled ball is converted into puddled bars by shingling, blooming, and rolling. Cf. MILL.

Forged Scrap Iron (*Eng.*) Small pieces of waste wrought iron from the smith's shop which have been welded up into bars. If properly welded up, this scrap is of considerable value, and often preferable to new rolled bars, on account of its strength. *See also* FAGOT.

Forged Work (*Eng.*) Wrought iron work prepared by the blacksmiths.

Forge Pigs (*Met.*) Pig iron suitable for conversion into wrought iron by PUDDLING (*q.v.*)

Forge Scale (*Eng.*) The scales or flakes of black oxide of iron produced in working wrought iron.

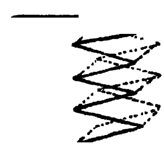
Forge Tests (*Eng.*) Tests applied to wrought iron and steel by bending. The greater the angle through which a plate or bar bends without fracture, the better the iron; this angle is often stated in specifications. The test may be applied both to hot and to cold iron.

Forge Train (*Met.*) A train of two pairs of rolls (ranging from roughing rolls to finishing grooves) in which the shingled bloom from the squeezers or steam hammer is rolled into slabs or bars without reheating. Also called PUDDLING ROLLS. They revolve at 50-80 revolutions per minute.

Forging Machines (*Eng.*) Machines by which definite shapes can be given to wrought iron by forcing it into discs, etc., either by a powerful press or by mechanically driven hammers or stamps.

Fork (*Cycles*). The portion of the machine in which the wheel revolves. In motor cycles the front forks are built up of several rods instead of two only, to make them sufficiently strong to stand the heavy stresses.

Forked Heading Joint (*Joinery*). A joint used in fastening two boards end to end. The ends of the boards to be joined have V-shaped pieces cut out to intersect with each other.



FORKED HEADING JOINT.

Forked Lightning (*Meteorol.*) The ordinary form of lightning, resembling an electric spark on a very large scale. The term "forked" is really a misnomer, as the spark is sinuous or wavy, with branches like a river and its tributaries.

Form (*Art*). A term used to denote the qualities of *line* as distinguished from colour.

—— (*Min.*) *See* SYSTEMS OF CRYSTALS.

—— *or* **Forme** (*Typog.*) Pages of type or stereotype plates arranged in the order for printing a sheet (*q.v.*), and secured by an iron frame or chase (*q.v.*)

Formaldehyde (*Chem.*) $\begin{matrix}H\\|\\HCO\end{matrix}$ (Formic aldehyde). A gas with penetrating smell. When liquefied it boils at $-21°C$. Ordinarily it is met with in aqueous

solution. It is prepared by passing the vapour of methyl alcohol mixed with air through a heated tube containing copper gauze. It is a powerful disinfectant, and a 40 per cent. solution is sold under the name of FORMALIN for disinfecting purposes; a trace of it added to milk will keep the milk fresh for several days. It has the usual reactions of an aldehyde, except with ammonia, with which it yields hexamethyleneamine (or hexamethylenetetramine), $(CH_2)_6N_4$, a crystalline solid readily soluble in water: used in medicine under the name UROTROPINE as a urinary antiseptic. Formaldehyde readily reduces silver and gold solutions to the metallic state. When its aqueous solution is evaporated, it polymerises to paraformaldehyde, $(CH_2O)_n$, an amorphous solid which yields formaldehyde vapour on heating. Used in this way as a disinfectant under the name PARAFORM. When a weak solution of formaldehyde is allowed to stand with slaked lime, it undergoes condensation to a substance FORMOSE, from which a fermentable sugar called methose has been obtained, which is identical with α-acrose (inactive lævulose). Formaldehyde is believed to play an important part in the formation of starch by plants. Under the influence of the chlorophyll the atmospheric carbon dioxide is changed to formaldehyde, which is then polymerised to a sugar, from which the starch arises.

Formalin (*Chem.*) *See* FORMALDEHYDE.

Format (*Printing*). The dimensions of a book (shape, size), *e.g.* octavo, quarto, etc.

Formates (*Chem.*) Salts of FORMIC ACID (*q.v.*)

Formation (*Geol.*) A name applied, in a somewhat vague sense, to an assemblage of rocks which have some character in common, generally that of age; but the term is used also in referring to the origin of the rocks or to their petrographical character. Thus rocks are said to belong to the stratified formation as distinguished from eruptive; to ancient, as distinguished from modern formation to calcareous, as distinguished from argillaceous, arenaceous, or other formations. Of late years terms of more precise meaning have begun to come into use to express each of these several ideas.

Formation of Clouds (*Meteorol.*) *See* CLOUDS.

Former (*Eng., etc.*) (1) A general name for a tool used to produce some one definite shape in a piece of metal. (2) A TEMPLATE (*q.v.*) or gauge used to test some shape when produced.

Formeret (*Architect.*) A wall rib. *See* RIB AND PANEL VAULT *and* WALL RIB.

Formic Acid (*Chem.*) $\begin{matrix} H \\ | \\ COOH. \end{matrix}$ A pungent smelling liquid; boils at 101° C.; soluble in water; blisters the skin (cause of sting of ants and nettles). It occurs in nettles and in ants, and was formerly prepared by distilling the bodies of red ants. It is prepared by distilling oxalic acid with glycerine at 110° to 115° C.; the weak acid (46 per cent.) so obtained is boiled with lead oxide, and the lead formate which crystallises out is dried and treated with sulphuretted hydrogen at 100°, any sulphuretted hydrogen dissolved in the anhydrous acid so obtained being removed by standing over lead formate. The acid reduces ammoniacal silver to the metal $HCOOH + Ag_2O = 2Ag + CO_2 + H_2O$. Heated with sulphuric acid it gives pure carbon monoxide and water. Its salts (the formates) are all soluble in water. Sodium or potassium formate heated with caustic soda gives *pure* hydrogen, $HCOONa + HONa = H_2 + Na_2CO_3$. Ammonium formate, when heated, first gives formamide, $HCONH_2$, then hydrocyanic acid, HCN, by loss of first one and then a second molecule of water.

Formic Aldehyde. *See* FORMALDEHYDE.

Formose (*Chem.*) *See* FORMALDEHYDE.

Forms of Clouds (*Meteorol.*) *See* CLOUDS.

Formula, Chemical. *See* CHEMICAL FORMULÆ.

Forte (*Music*). Loud. *See* "*f.*"

Fortin's Barometer. *See* BAROMETER.

Fortissimo (*Music*). Very loud. Represented by the letters *ff.*

Forum. In ancient Rome the place of assembly for the people, and where judicial and public business was transacted. It occupied a space between the Capitol and the Palatinate Hill. In the time of the Empire the term was extended to the public place or market place of all towns under Roman sway.

Forward Eccentric (*Eng.*) The eccentric (*q.v.*) which drives the slide valve of an engine while it is running in the forward (or usual) direction.

Forwarding (*Binding*). This expression covers all the operations performed in bookbinding up to the time a volume is covered with leather, vellum, etc., when the book is sent to the finishing shop for the gilding. *See* FINISHING.

Fossicker (*Mining*). A person employed in picking up stray pieces of ore from the rock after the main part of the vein has been worked.

Fossicking (*Mining*). Picking out stray fragments of ore after the lode has been worked.

Fossil (*Geol.*) Literally and originally anything that was dug up, but now restricted to organic remains which have been entombed in any of the rocks composing the earth's crust. The science that deals with fossils is palæontology, which is really a branch of biology. With the great extension of knowledge relating to fossils which has taken place within the last fifty years, palæontology has advanced so much that many different branches have arisen, each of which occupies the attention of specialists.

Foucault's Currents (*Elect.*) Currents produced in a mass of iron (or other conductor) when moved across a magnetic field. In electric machinery these currents cause loss of energy, and are kept down as much as possible, usually by dividing up the iron into laminæ parallel to the lines of force which cause the currents. The lines of force have a continuous path, but the Foucault currents have not, and are thereby checked.

Foucault's Measurement of the Velocity of Light. *See* VELOCITY OF LIGHT.

Foulard (*Silk Manufac.*) A thin soft silk cloth, used for ties, mufflers, handkerchiefs, etc.

Fouling (*Eng.*) (1) The deposition of SCALE (*q.v.*) and mud in a steam boiler. (2) The deposition of carbon, etc., in the cylinders, valves, and ports of internal combustion engines. (3) The products of combustion which are deposited in gun barrels, etc.

Foundation Cylinder (*Eng.*) A heavy cast iron cylinder sunk in the ground and often filled with

concrete. It serves to support the foundations of heavy structures or machines when the surrounding ground is not very firm.

Founding. (1) The process of forming an article by pouring molten metal into a mould. *See* CUPOLA *and* FOUNDRY.

—— (*Glass Manufac.*) The period when the furnace is raised to a high temperature in order to fuse the raw materials quickly into glass.

Foundry (*Eng.*) The workshop where castings are made. An IRON FOUNDRY is usually on the ground floor; it is provided with cupola furnaces, cranes, moulding boxes, etc., and has a floor covered with a thick layer of sand. In this floor pits are formed in which large castings are made.

Foundry Ladle (*Eng.*) A heavy iron vessel used for carrying molten iron from the furnace to the moulds in which castings are made. Before being used it is lined or coated with fireclay, which must be thoroughly dry before the molten iron is "tapped" or run into it.

Foundry Pig Iron (*Eng.*) Iron suitable for making castings, but not for conversion into wrought iron.

Foundry Pit (*Eng.*) A large hole or pit in the ground, in which very heavy or very deep castings are made. The mould may be contained in FLASKS (*q.v.*) or may be actually formed in sand, which fills the pit itself.

Foundry Sand (*Eng.*) Sand composed chiefly of silica, and free from earthy matter: used to form the moulds for castings.

Foundry Stove (*Eng.*) A stove used for drying cores and small moulds before they are used for making a casting.

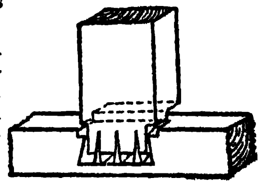
Four Cutter (*Carp., etc.*) *See* PLANING MACHINE.

Fourdrinier (*Paper Manufac.*) The paper machine, so called from the name of the inventor.

Fourier's Theorem (*Phys., etc.*) A periodic curve of any given shape can be formed by compounding together a number of sine curves whose frequencies are simple multiples of one initial sine curve, and whose amplitudes are suitably chosen. The initial or fundamental curve has the same period as the given curve; the successive sine curves will then have frequencies once, twice, three times, etc., the fundamental one. It follows that any wave of complex shape (*e.g.* a sound wave which is not that of a simple tone) can be produced by the combination of a number of waves, the fundamental one having the same period as the given complex wave, the remaining ones having frequencies which are simple multiples. In sound, these remaining tones are the partials or harmonics or the first or fundamental tone; the resulting complex tone has the same pitch (frequency) as the fundamental tone, but of a different quality or "timbre." This difference in timbre is due to the presence of the partials. (*See also* TIMBRE.) The general theorem is expressed mathematically by means of FOURIER'S SERIES. If y be a quantity which varies periodically, going through a complete cycle of changes in time T, then its value at any time t is given by the equation $y = a_0 + a_1 \sin pt + a_2 \sin 2\,pt + a_3 \sin 3\,pt +$ etc., $+ b_1 \cos pt + b_2 \cos 2\,pt + b_3 \cos 3\,pt +$ etc., where a_0, a_1, b_1, b_2, etc., are constant coefficients and $p = \frac{2\pi}{T}$. The equation may also be written y $A_0 + A_1 \sin (pt + e_1) + A_2 \sin (2\,pt + e_2) + A_3 \sin (3\,pt + e_3)$, etc., where $A_1{}^2 = a^2 + b^2$ and $\tan e_1 = \frac{b_1}{a_1}$, the other coefficients A_2, A_3, etc., being similarly obtained.

Four Part Vault (*Architect.*) *See* QUADRIPARTITE VAULT *and* VAULT.

Fox Wedging. A method of wedging tenons without showing the wedges on the edge of the work.



FOX WEDGING.

Foxy (*Chem. Eng.*) A brownish shade which develops in soap made from palm oil or tallow bleached by the muriatic = bichromate, or the chlorine processes. It is attributed to the temperature being too high in the former process, and to excess of chlorine attacking the fatty glycerides in the latter.

Fogging (*Dec.*) A defect of enamelled work in which the surface becomes clouded like blooming in varnish (*q.v.*), caused by the enamel being applied during damp weather.

Fraction (*Chem., etc.*) A portion of a distillate which passes over, or distils, at or about one given temperature. *See* FRACTIONAL DISTILLATION.

Fractional Crystallisation (*Chem.*) A method of resolving a mixture of substances of different solubilities into its constituents by a systematic process of recrystallisation. Suppose the mixture consists of two substances; then on dissolving it in a suitable solvent and leaving to crystallise, the crystals first deposited will be richer in the less soluble substance: these crystals are again dissolved in a fresh portion of the solvent, and left to crystallise—the crystals will be still richer in the less soluble constituent. Crystals may now be obtained from the first mother liquor and recrystallised from the second mother liquor, and so on, until a separation is effected. This process of fractional crystallisation applied to the rare earths has resulted in the discovery of new elements. Marignac discovered gadolinium and samarium in samarskite by fractional crystallisation of the double potassium sulphate salts. Auer von Welsbach discovered neodymium and praseodymium in didymia by fractional crystallisation of the double ammonium nitrate salts.

Fractional Distillation (*Chem., etc.*) A method of separating a mixture of substances into its components by distillation (*q.v.*) Coal tar consists of a very large number of substances. When distilled, the following fractions are collected: (1) Up to 110°; (2) 110° to 210°; (3) 210° to 240°; (4) 240° to 270°; (5) 270° to 400°. From each of these fractions various substances are obtained by a second "fractionation"; *e.g.* from the first fraction after removal of basic and acid substances, benzene, boiling at 81°, and toluene, boiling at 110°, are obtained fairly pure. But in some cases a mixture of only two substances cannot be separated into its constituents by fractional distillation. Alcohol and water cannot be completely separated. If the liquid contain a small amount of alcohol, all the latter and some water can be separated by distillation, leaving water behind; but on repeating the process on the distillate, a stronger alcohol than 95 per cent. cannot

be obtained. Other liquid pairs form mixtures with constant boiling points: thus a mixture of 75 per cent. of formic acid and 25 per cent. of water distils unchanged and has a higher boiling point than any other mixture of these two liquids. *See also* GAS MANUFACTURE: COAL TAR DISTILLATION.

Fractional Pitch (*Eng.*) A screw is said to have a fractional pitch when the number of threads per inch is not a simple multiple or sub-multiple of the number of threads per inch on the leading screw of the lathe on which it is cut.

Fraction of Saturation (*Meteorol.*) The ratio of the pressure of the water vapour actually present in the air to the saturation pressure. Also termed RELATIVE HUMIDITY.

Fracture (*Min.*) A term used to designate the way in which a mineral breaks when the fracture is not due to cleavage (*q.v.*) Fracture may be (1) CONCHOIDAL, as in many glassy minerals, *e.g.* quartz; (2) EVEN, when the plane of division is fairly flat, *e.g.* chert; (3) UNEVEN, *e.g.* copper pyrites; (4) HACKLY, when it is somewhat granular and uneven, *e.g.* cast iron; and (5) EARTHY, *e.g.* chalk.

——, **Surface of** (*Eng.*, *etc.*) The form and nature of the fractured surface in a piece of material broken in the testing machine (or otherwise) gives certain indications of the quality of the material and often of the nature of the stress to which it has been subjected. In the case of metals such as iron it is useful to note whether the surface is crystalline, granular, or fibrous, as the quality of the iron can be inferred to a very large extent from the information thus obtained.

Fragaria (*Botany*). A genus of the order *Rosaceæ*. A well known species is the strawberry, whose fruit consists of a fleshy flower axis (thalamus) bearing numerous seedlike achenes.

Fraise (*Cost.*) A collarette or ruff, much worn during the sixteenth century: a Medici collar.

Fraises (*Her.*) Strawberry leaves as borne by frazer.

Frame (*Chem. Eng.*) A deep rectangular box into which a "made" soap is run from the copper or kettle, in order to cool into conveniently shaped blocks prior to cutting up. At one time the Excise authorities insisted on the frames being of definite proportions; *viz.* 45 in. long by 15 in. wide, and from 45 to 60 in. deep, but the size is no longer compulsory. They are usually made of iron or steel plates, the sides being detachable. There are many special patented types. The Continuous Drying System is superseding their use for toilet soaps and certain classes of "households."

Framed (*Carp.*) Woodwork put together with mortice and tenon joints.

Framed and Braced Door (*Carp.*) A framed door with diagonal braces. The spaces are usually filled in with battens in lieu of panels.

Framed Floor (*Carp. and Join.*) This consists of girders, binders, ceiling joists, bridging joists, and flooring boards. *See also* FLOORS.

Framed Grounds (*Carp.*) Grounds which are put together with mortice and tenon joints. *See* GROUNDS.

Framed Partition (*Joinery*). A partition constructed of panelled framing.

Frame House (*Build.*) (1) A half-timbered house (*q.v.*) (2) A modern building, usually of a more or less temporary character, constructed of wooden framing covered with board, shingling (*q.v.*), corrugated iron, etc. Commonly used in colonies and newly settled districts.

Frame Saw (*Carp.*) A straight saw, or set of parallel saws, fixed in a reciprocating frame, and used for cutting deals or logs into boards.

Frame Wall (*Build.*) A wall formed of a framework of timber, the spaces being filled in with brickwork or masonry. *See also* HALF TIMBERED WORK.

Frame Weirs (*Civil Eng.*) Weirs in which the water is held up by doors carried by heavy frames. These doors can be removed when required. *See* NEEDLE PANEL *and* ROLLING UP CURTAIN WEIRS.

François Vase. *See* VASES.

Frankfort Black (*Dec.*) *See* DROP BLACK.

Frankincense. This resin (also called GUM OLIBANUM) is an exudation from the stem of a tree, *Boswellia carteri* (order, *Burseraceæ*), grown in Somaliland.

Franking (*Carp. and Join.*) A method of joining the cut bars in sashes.

Franklinite (*Min.*) A complex oxide containing iron in the ferrous and ferric state ($FeO \cdot MnO \cdot ZnO$) ($Fe_2O \cdot Mn_2O_3$). Equivalent composition, ferric oxide = 64—66; manganic oxide = 11—18, zinc oxide = 11—25 per cent. Cubic, in black octahedra, and massive. It has a reddish brown streak, and is hard and tough. Chiefly from New Jersey.

Fraunhofer's Lines (*Astron.*) The dark lines crossing the spectrum of the sun in different places. *See* SPECTRUM *and* SPECTRUM ANALYSIS.

Freeman's White (*Dec.*) A non-poisonous white pigment consisting principally of sulphate of lead made from metallic lead by precipitation. It contains also zinc oxide and barytes. It is not affected by sulphurous gases like white lead is, and it possesses good body and covering power.

Free Sand (*Foundry*). Sand which forms a porous mould or core, allowing the escape of gas from the mould.

Free Spring (*Watches*). A balance spring without an "index" or "regulator." Used only in the highest grade watches, as the spring has to be regulated by an expert who moves the timing screws inwards or outwards. More accurate timekeeping is thus obtainable, as any movement of an index might disturb the isochronism. *See* BALANCE SPRING; INDEX; ISOCHRONISM.

Freestones (*Build.*) Stone which does not readily split into layers, *i.e.* which does not possess well marked planes of cleavage. Most suitable for carving. The term is applied in many districts to sandstones (*q.v.*)

Free Vibrations (*Phys.*) The natural vibrations of a body or system when left to itself, as distinguished from forced vibrations (*q.v.*) A body vibrating freely has in general a definite and fixed period of vibration, depending on the mass of the body and the amount of the restoring force exerted on it when a small displacement from its position of equilibrium is produced.

Freewheel (*Cycles*). *See* CYCLES.

Freezing (*Heat*). The process of solidification or changing from a liquid to a solid condition. *See* FREEZING POINT.

Freezing Mixtures. Usually a mixture of some soluble salt with snow, powdered ice, or merely cold water. The rapid solution of the salt lowers the temperature of the mixture. Thus sodium chloride mixed with snow will give a temperature of $-22°$ C., calcium chloride and snow about $-55°$ C., ammonium nitrate and snow $-17°$ C. The best mixture is solid carbonic acid dissolved in ether, which can be made to give $-77°$ C.

Freezing Point (*Phys.*) The temperature at which a liquid substance changes or commences to change into its solid form. In a great number of cases the freezing point is not definite, as in the case of glass, which softens and gradually changes into a viscous solid when heated, and reverses this process when again cooled. The freezing point of a liquid is affected by several conditions, the most important being the variation of pressure. Increase of pressure lowers the freezing point of all those substances which expand on solidification (*e.g.* water), and raises the freezing point of substances which contract on solidification (*e.g.* wax and sulphur). FREEZING POINT OF SOLUTIONS: In general, the freezing point of a solution is lower than that of the solvent. The amount of depression of the freezing point is proportional to the number of dissolved molecules. If the molecules of the dissolved substance are not dissociated (or broken up into simpler molecules) when dissolved, there will be a simple relation between its molecular weight and the depression of the freezing point. If M = molecular weight of the dissolved substance, *m* the weight dissolved in 100 grams of the solvent, *t* the observed depression of the freezing point, then

$$t = K\frac{m}{M},$$

where K is a constant depending on the nature of the solvent employed. The value of K can be found by experiment, or calculated by purely theoretical considerations based upon thermodynamics. If L is the latent heat of fusion of the solvent, T the temperature at which it freezes if pure, then

$$K = \frac{\cdot 02T^2}{L}.$$

The value of K is about 19 for water, 40 for acetic acid, 50 for benzene, 70 for nitrobenzene. The freezing point of dilute solutions is usually determined by means of Beckmann's apparatus. A weighed quantity of the solvent is placed in a tube resembling a test tube, but provided with a side tube through which the substance which is to be dissolved can be introduced. A delicate thermometer divided into hundredths of a degree, and also a platinum stirrer, are introduced into the tube through a cork at the top. This tube is surrounded through the lower half of its length by an air jacket, which is in turn surrounded by a large vessel in which a suitable freezing mixture is placed to effect the requisite lowering of the temperature of the solvent. The freezing point of the pure solvent is first observed, then the tube is removed, the given substance introduced and dissolved in the solvent, and the tube is replaced. The freezing point of the solution can be observed.

French Arch (*Build.*) An inferior form of arch, built of ordinary bricks, which are not cut or rubbed to form true voissoirs, but left in their original form with parallel sides. It is sometimes used to form a horizontal top to an opening, the bricks starting from a sloping jamb and meeting at an angle in the centre.

French Casement (*Build.*) A pair of glass doors in a solid frame.

French Chalk (*Min.*) A variety of steatite or talc (*q.v.*) It is used in marking out cloth, and when powdered it is dusted on to various articles to prevent anything sticking to them, or to act as a lubricant. *See also* SOAPSTONE.

French Curves. A thin plate of wood (usually pear tree), with its edges cut into a series of curves of various radii. Used in drawing curves, not easily obtained geometrically, after certain points on the curves have been found.

French Polishing (*Dec.*) A method of polishing hard wood by applying a special polishing varnish made of gums dissolved in spirit. The recipes for French polishes differ a great deal. One of the best is 1½ lb. of orange shellac dissolved in 1 gal. of methylated spirit, to which has been added 2 oz. of gum sandarach and 2 oz. of gum benzoin. The woodwork to be polished is first "filled" by rubbing in a mixture of plaster of paris and Russian tallow. This having been effected, the polish is applied with a rubber formed of white linen or cotton in such a way as to present a convex surface. The rubber is moistened with linseed oil and polish, and the wood is rubbed with a circular motion, very lightly at first, but with increasing pressure as the work proceeds. The final operation is "spiriting off," which consists in rubbing on prepared spirit, which is prepared like the French polish, excepting that there is a much larger proportion of methylated spirit.

French School of Painting. *See* PAINTING, SCHOOLS OF.

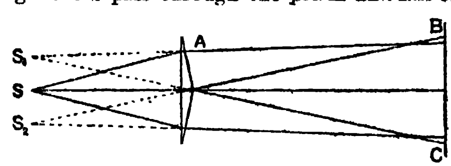
Frequency (*Phys., etc.*) The number of times which a vibration (or other recurring phenomenon) occurs per unit of time; *e.g.* the number of vibrations per second of a tuning fork is termed the FREQUENCY of the fork, or, more correctly, its FREQUENCY OF VIBRATION.

Fresco Painting. *See* PAINTING, METHODS OF.

Freshwater Deposits (*Geol.*) Strata laid down in rivers or in lakes, as distinguished from those deposited upon the land, or in estuaries, or beneath the water of the sea.

Fresnée (*Her.*) Standing on its hind legs.

Fresnel's Bi-Prism (*Light*). A double prism of small angle, as shown at A. If a narrow beam from a single slit S pass through the prism and fall on a



FRESNEL'S PRISM.

screen BC, it will behave as if it came from two sources S_1 and S_2, and interference fringes will be seen on the screen BC. *See also* INTERFERENCE.

Fresnel's Mirrors (*Light*). An arrangement of two mirrors placed with their edges touching and their surfaces inclined at an angle of nearly 180°. Light from a single source falls on the mirrors, and

is reflected so as to fall on a screen. Two beams, inclined at a very small angle, are thus obtained, and interference bands are produced on the screen in a manner similar to those formed by means of Fresnel's Bi-Prism (*q.v.*)

Fresnel's Rhomb (*Light*). A rhomb of glass so constructed that a ray entering along the normal to one end is reflected from the side (by total internal reflection) at an angle of 55°. It then strikes the other side, and is again totally reflected at the same angle, and emerges along the normal to the other end. If the incident light be polarised at an angle of 45° to the plane of incidence, the emergent light will be circularly polarised. If the incident light be circularly polarised, the emergent beam will be plane polarised. The rhomb therefore serves for testing circularly polarised light.

Fret (*Architect.*) A classical ornament used on a flat surface, and consisting of a series of fillets intersecting, usually at right angles, so as to form various patterns.

Frets (*Music*). The small transverse pieces of wood on fingerboards of guitars, zithers, etc., immediately above which the finger must be placed on the string to produce a given note.

Fret Saw (*Carp., etc.*) A very fine saw fixed in a frame, and worked by hand or driven by a machine. It is used in cutting out complicated patterns in thin wood.

Frette (*Her.*) A subordinary: consisting of a saltire and a mascle.

Friction (*Phys.*) The force between two bodies in contact, which tends to prevent their relative motion.

——, Coefficient of. If a body resting on a surface exert on the surface a normal pressure P, it is found that the force F exerted by friction is a certain fraction of the pressure. This fraction is called the COEFFICIENT OF FRICTION, and is usually denoted by the Greek letter μ. We then have $F = \mu P$.

Friction Coupling (*Eng.*) A coupling (*q.v.*) in which the two parts are caused to rotate together by the friction between the two halves of the coupling. These two halves are of various forms; a hollow and a solid cone fitting into each other are often used.

Friction Gearing (*Eng.*) Wheels which are caused to rotate together by the friction of one on the other, instead of by means of teeth. This arrangement is only used, as a rule, to transmit a very small amount of power.

Friction, Kinetic. The amount of the frictional force between two bodies while in motion is termed the KINETIC FRICTION. It is usually less than the static friction. *See* FRICTION, STATIC. Some examples of the coefficients of Kinetic friction are:

Iron on oak, surfaces dry	·62
„ „ „ surface soaped . . .	·21
Iron on iron, very slightly lubricated .	·15
„ „ „ surfaces well lubricated .	·04—·05

Friction Rollers (*Eng., etc.*) Small wheels used to support the axle of a larger wheel. The small wheels rotate, and thereby abolish sliding friction between the axle and its bearing. Ball bearings (*q.v.*) depend upon the same principle, and are superior to rollers.

Friction, Static. The amount of the frictional force between two bodies when just on the point of moving relatively to each other is called the STATIC FRICTION, and the ratio of the frictional force to the pressure of one body on the other is called the COEFFICIENT OF STATIC FRICTION.

Friedel and Craft's Reaction (*Chem.*) Originally only a method of preparing alkyl benzenes by the action of aluminium chloride upon benzene, and an alkyl bromide or iodide, *e.g.*

$$\underset{\text{Benzene.}}{C_6H_6} + C_2H_5Br = \underset{\text{Ethyl Benzene.}}{C_6H_5C_2H_5} + HBr.$$

The reaction has been greatly extended; *e.g.* acid radicals can be introduced in place of alkyl radicals by using an acid chloride in place of an alkyl chloride or bromide, and benzene derivatives can be used in place of benzene itself. The reaction is also a reversible one. Thus, if aluminium chloride be added to toluene and hydrochloric acid gas passed into the mixture, benzene is obtained, and the liberated methyl chloride acts upon unchanged toluene, forming metaxylene and paraxylene.

Frielsebenite (*Min.*) A sulphantimonite of lead and silver, $5(PbAg_2)S \cdot 2Sb_2S_3$. Monosymmetric. The silver amounts to 22 or 23 per cent., so when at all plentiful it is a valuable ore of silver. From Saxony, Spain, and Bohemia.

Frieze (*Architect.*) The central division of an entablature between the architrave and the cornice. It is sometimes spoken of as the ZOOPHORUS. The term "frieze" is also used to denote any band of sculptured ornament and that division of the wall surface of a room immediately below the cornice. *See* ARCHITECTURE, ORDERS OF; ENTABLATURE; ZOOPHORUS.

—— (*Woollen Manufac.*) A thick woollen nap overcoating. Usually made in Ireland.

Frieze Panels (*Joinery*). An upper row of panels, especially the highest panels in a six panelled door.

Frieze Rail (*Joinery*). The rail between the top of a door and the middle rail: used in a six panelled door.

Frilling (*Photo.*) An expansion of the gelatine film by which it forms in wrinkles on the plate. This frequently accompanies the use of too soft a gelatine. It may also be caused by too strong a fixing bath.

Fringe. A border or edging, generally consisting of a narrow band to which are attached threads of some material, either twisted or hanging loose. A fringe may be formed also by leaving the threads of the warp in a fabric after weaving.

Frisbie's Feeder (*Glass Manufac.*) *See* FURNACES, GLASS.

Frisket (*Printing*). An iron frame on which a sheet of paper is pasted. It is used in conjunction with the tympan of a hand press. Its purpose is to lift the printed sheet from the forme and preserve the margins clean.

Frizing (*Leather Manufac.*) Removal of a very thin layer from the grain surface of the skin is called frizing. Buff leather and much glove leather is "frized." *Cf.* BUFFING.

Frog (*Build.*) The recess on one side of a brick.

—— (*Cotton Manufac.*) A cast iron buffer for the stop rod of a shuttle protector of the fast reed type.

Front Hearth (*Build.*) The portion of a hearth in front of the chimney breast.

Frontispiece. The principal illustration in a book or magazine. It faces the title page of a book or other bound volume, but in a magazine the first page of letterpress.

Front Putty (*Build.*) The putty put outside the glass after it is inserted in the sash.

Frost (*Meteorol.*) When the thermometer sinks below the freezing point of water (0° C. = 32° F.) a frost occurs. Sometimes in the British Isles prolonged frosts take place extending over many weeks.

——, Geological Action of. Water finds its way from the surface into the divisional planes and other interstices of rocks of all kinds. When a frost comes, the water in the parts near the surface freezes, and expands in doing so, 174 volumes of water becoming 184 volumes of ice. This expansion takes place with a force which is equal to a pressure of 1,100 lb. to the square inch for each degree below the freezing point. As the temperature falls below freezing the ice contracts, and water may flow in to take its place, freezing in its turn. With a thaw the ice again expands. Hence powerful mechanical forces are exerted, and the surface layers of the rock are shattered.

Fructed (*Her.*) With seeds or fruit.

Fructose (*Chem.*) LÆVULOSE (*q.v.*)

Frue Vanner (*Mining*). A machine by which crushed ore is shaken up under moving water on a wide belt; a separation of the lighter from the heavier parts of the ore gradually results.

Fruit (*Botany*). That part of the flower which remains after fertilisation. The ripened ovary containing the seeds is the essential part of the fruit.

Fruit Sugar (*Chem.*) LÆVULOSE (*q.v.*)

Fuchsine (*Chem.*) Also called Magenta; it is a mixture of the hydrochloride or acetate of rosaniline and pararosaniline, obtained by oxidising a mixture of aniline, orthotoluidine, and paratoluidine. It is a lustrous green solid, dissolving in water with a splendid red colour. Used in dyeing silk, wool, cotton, and leather. *See* PARAROSANILINE *and* ROSANILINE.

Fucus Vesiculosus (*Botany*). The Bladder Wrack. It is one of our commonest brown seaweeds. Together with other species of *Fucus*, it is used as a manure and also as a drug for reducing corpulence.

Fuel. The material which is burnt to produce heat in furnace, etc. *See* COAL, COKE, OIL FUEL, *etc.*

Fughetta (*Music*). A small fugue, *i.e.* not developed at any length.

Fugue (*Music*). A contrapuntal composition consisting of the following parts:—(1) Subject: the theme on which the fugue is founded, generally given out by one part in the score. (2) Answer: the response to the subject; generally a transposition of the subject from the key of the tonic to that of the dominant. If the answer is an exact transposition, it is called a "Real Fugue"; if modified to save modulation, then it is called a "Tonal Fugue." The answer is accompanied by the first voice, or part, and this accompaniment is known as the "counter subject," and is generally in double counterpoint. (3) Exposition: that section of a fugue ending with the last entry of subject or answer (according to the number of parts) by the part that last enters. (4) Episode: free passages developed from material already heard, and serving the double purpose of variety and modulation. These episodes lead back to fresh entries of the subject or answer in new keys. (5) Stretto: the drawing closer together of subject and answer which is often found towards the end of fugues. Besides these parts there is often found a codetta—a few notes inserted between the subject and answer to lead more naturally from one to the other. The greatest master in this branch of composition was Bach.

Fulcrum. The point about which a lever turns.

Full (*Eng.*) A loose expression indicating that the dimensions of some object slightly exceed their nominal value: the opposite of BARE (*q.v.*)

Full Bound *or* **Whole Bound** (*Bind.*) Applied to a book the covers of which are completely covered in leather or some expensive material. The highest style of work.

Fullering (*Eng.*) (1) Producing grooves in forged work. (2) Caulking a boiler by hammering down the edge of the plates.

Fullering Tool (*Eng.*) A tool whose end is suitably shaped for producing grooves of some required section. *See* FULLERING.

Fuller's Earth (*Geol.*) Literally a kind of clay which readily absorbs grease, and especially the oily matter found in connection with sheep's wool. In a geological sense the Fuller's Earth is a member of the Jurassic rocks, and is essentially a series of beds of clay and marl with nodular masses of earthy limestone. It includes some bands of clay suitable for the purpose indicated by its name. In composition it is a hydrous aluminium silicate of the approximate composition, silica = 45, alumina = 20, water = 25 per cent., with other substances to 10 per cent. Found in various dull shades of grey, green, and brown. Soft and earthy; soapy to the touch; very porous. From Reigate and Bletchingly in Surrey; near Bath, Kent, etc.

Full Gear (*Eng.*) An engine is in full gear when the link motion (*q.v.*) is set so as to produce the greatest amount of motion or travel of the slide valve.

Fulling (*Woollen Manufac.*) *See* FELTING.

Full Moon (*Astron.*) The moon when in opposition (*q.v.*) and appearing fully illuminated.

Full Shroud (*Eng.*) A SHROUD (*q.v.*) on a toothed wheel extending right up to the tips of the teeth.

Full Thread (*Eng.*) A screw with its thread cut to its proper section; one which is properly completed, as distinguished from a partly cut thread.

Fulminates (*Chem.*) Salts of FULMINIC ACID (*q.v.*)

Fulminating Gold (*Chem.*) $AuN.NH_3.3H_2O$. A green or brown solid obtained by the action of ammonia on auric oxide. When dry it explodes on percussion or on heating.

Fulminating Silver (*Chem.*) NAg_3. A black solid obtained by allowing a solution of silver oxide in ammonia to evaporate. It is very explosive when dry; if touched with a feather it explodes; less explosive when wet.

Fulminic Acid (*Chem.*) $C:NOH$. The free acid is not known in a pure condition, owing to its in-

stability; it decomposes when liberated from its salts by acids, forming hydroxylamine and formic acid. It smells like prussic acid, and is poisonous. MERCURIC FULMINATE, $(C:NO)_2Hg$ (fulminating mercury), is obtained by dissolving mercury in nitric acid and adding alcohol. It forms white needles, insoluble in water. On heating or on percussion it explodes violently, forming carbon monoxide, nitrogen, traces of other gases (CO_2 and H_2), and mercury: it is very largely used in the preparation of percussion caps and detonators for other explosives. Strong hydrochloric acid yields fulminic acid, which decomposes as above. With benzene and aluminium chloride it yields benzaldoxime, $C_6H_5C:NOH$ (proof of constitution). SILVER FULMINATE resembles mercury fulminate, and is prepared in a similar way. It is more explosive than the mercury salt, friction with a glass rod being quite sufficient to explode it.

Fumant (*Her.*) = smoking.

Fumaric Acid (*Chem.*)
$$\begin{array}{c} H.C.COOH \\ \| \\ HOOC.C.H \end{array}$$
. A white crystalline solid sparingly soluble in water. It occurs in Iceland moss and in certain fungi. It is obtained from mallic acid (*q.v.*), with which it is stereoisomeric (*see* STEREOISOMERISM) by heating in a sealed tube to 200°, or by acting upon it with hydrochloric acid. On heating, it gives maleic anhydride and water. Potassium permanganate oxidises it to racemic acid (*q.v.*)

Fumarole (*Geol.*) A volcanic vent from which only gaseous products escape.

Fundamental Bass (*Music*). That note from which a chord is built up; also called the root.

Fungi (*Botany*). A lowly class of plants of parasitic or saprophytic habit, and devoid of chlorophyll. They range from the simple thread-like moulds to the complex mushrooms and toadstools.

Funicle (*Botany*). The stalk which attaches the ovule to the placenta.

Funnel (*Eng.*) The chimney of a marine boiler: sometimes applied to that of a locomotive or portable engine.

Fur. The long silky hair of many mammals. The furs of commerce are derived from the hare, rabbit, beaver, sable, bear, marten, stoat, etc.

—— *or* **Fir** (*Build.*) To support a ceiling, etc., by FURRING (*q.v.*)

Furcræa (*Botany*). A genus of the *Amaryllidaceæ*, *F. gigantea*. From tropical America; yields a valuable fibre called MAURITIUS HEMP.

Furfuraldehyde (*Chem.*)
$$\begin{array}{l} CH = CH \\ | \qquad\quad >O \\ CH = C.CHO \end{array}$$
. A colourless liquid smelling like benzaldehyde: turns brown on exposure to air: somewhat soluble in water: readily soluble in alcohol and in ether: can be detected even in small quantity by the red colouration it gives with aniline in presence of hydrochloric acid. It is obtained by distilling bran with dilute sulphuric acid; also by distilling pentoses (*e.g.* Arabinose) with hydrochloric acid. In its chemical behaviour it bears an extraordinary resemblance to benzaldehyde; *e.g.* with dimethylaniline and zinc chloride it gives a green colouring matter analogous to malachite green (*q.v.*) By the action of dry hydrobromic acid gas on ketohexoses (*e.g.* lævulose) and on cellulose, a purple colouration is obtained: this is due to a furfuraldehyde derivative—α-brommethylfurfuraldehyde,
$$\begin{array}{l} CH = C.CH_2Br \\ | \qquad\quad >O \\ CH = C.CHO \end{array}$$
.

Furfurane (*Chem.*),
$$\begin{array}{l} CH = CH \\ \beta_1 \quad \alpha \\ \quad\;\; \alpha_1 >O \\ CH \;\; CH \end{array}$$
. A colourless liquid with characteristic smell; boils at 39°: insoluble in water. A pine shaving moistened with hydrochloric acid is coloured green by the vapour of furfurane. It occurs in pinewood tar. It is prepared by distilling barium pyromucate. *See* MUCIC ACID *and* ACETONYL ACETONE.

Furfurol (*Chem.*) FURFURALDEHYDE (*q.v.*)

Furlong. *See* WEIGHTS AND MEASURES.

Furnace, Electric. The electric furnace consists of an arrangement by which materials can be submitted to the heat of an electric arc. In one form (fig. 1) A is a metal case with a refractory lining B, inside which is placed a crucible C. Two carbon rods D and E are supported by holders G and H, insulated from the case. Materials can be introduced by removing the cover F. The current is supplied by leads K and L. The furnace requires a potential difference of 50 to 70 volts, and may use a current varying from 25 to 400 ampères. By the aid of a furnace of this form Moissan has fused lime, and has obtained calcium, chromium, etc., in the metallic form. The HÉROULT FURNACE is shown in fig. 2.

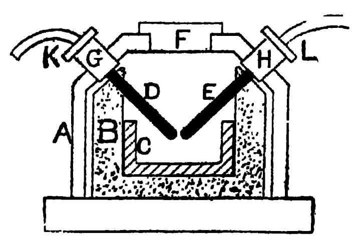


FIG. 1.—ELECTRIC FURNACE.

A is a casing of metal, B a lining built up of carbon plates cemented by carbonaceous matter, *e.g.* tar. This lining forms the crucible, and also serves as the cathode (*q.v.*) The anode consists of a number of plates of carbon E held in position by suitable clamps and insulated from the metal case A. Material can be introduced through openings at G and H, and fluid metal can be withdrawn through a tapping hole D. The current enters by conductors K and L. Aluminium is now produced by means of furnaces of this pattern.

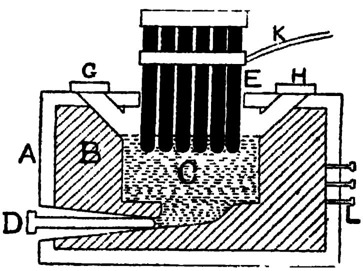


FIG. 2.—ELECTRIC FURNACE (HÉROULT).

Furnace Lining (*Metallurgy*). Infusible material, such as fireclay, which protects the main walls of a furnace from the action of the heat or the corrosive effect of the molten metal and slag. In certain cases (*e.g.* the Bessemer converter) the lining itself contains materials which contribute to the process by assisting in the formation of slag, etc.

Furnaces, Glass (*Glass Manufac.*) Glass furnaces may be classified either according to the method by which they are heated or the use for which they are intended. The principal forms are as follows:—DIRECT FIRING FURNACE: A furnace, circular or rectangular in plan, in which the fuel (coal or coke) is admitted either through an aperture at the side or ends, or from beneath. The latter method of supplying fuel may be effected by means of FRISBIE'S FEEDER, which is a mechanical contrivance for winding up fuel from beneath the grate bars, through a circular aperture, into the furnace. It consists of a bucket or hopper with a movable bottom, which is forced upwards by a lever connected to the machinery. GAS FURNACE: This is circular or rectangular. The most economical is Siemen's regenerative furnace. Coal undergoes destructive distillation in a gas producer, and the gases formed, after passing through a REGENERATOR, enter the furnace, where, on coming in contact with air, they burst into flame, producing intense heat. The hot gases, conveying waste heat from the furnace, are allowed to pass through other regenerative chambers (two pairs being employed), and these in their turn serve to heat up the gas as it passes from the producer, and also the air from outside, before it enters the furnace chamber. A TANK FURNACE is used for melting bottle and window glass. It consists of one long rectangular basin or tank, one end of which is semicircular, and at this end the working or gathering holes are situated. The raw materials are inserted at the opposite end. The furnace is heated by gas (Siemen's principle). Floating vessels (*q.v.*) are placed in the molten glass at the circular end, and from these the metal is gathered. LEAD GLASS FURNACE: This is circular in shape, and contains from eight to twelve pots, those in general use being about 36 in. wide by 40 in. high, hooded or covered over. Space is allowed between each pot as it stands upon the siege and within the furnace, to allow the hot gases to surround them previous to passing into flues, which are placed at each intervening space. The furnace can be worked either by direct firing or on the gas regenerative principle. SHEET GLASS FURNACE: This may be either a POT or TANK FURNACE, and can be worked as a direct firing or as a gas furnace. It is rectangular in plan, with an arched crown or roof. The pots, which are open at the top, are placed in parallel rows at the longest side of the furnace, which contains from eight to sixteen pots. A PLATE GLASS FURNACE is similar in construction, but before each pot hinged doors (lined with slabs of fireclay) are placed, to allow the pot to be removed from the furnace for casting purposes. A GLORY HOLE is a small furnace used for reheating the glass during manipulation or manufacture.

Furnaces, Metallurgical. Metallurgical furnaces may be classified as follows: (1) Furnaces in which the fuel and ore are in contact. These may be again divided into OPEN HEARTHS, constructed on very similar principles to the ordinary smith's forge, and which are suitable for simple operations such as ROASTING and LIQUATION (*q.v.*); and CLOSED HEARTHS, in which the furnace possesses a tall body of more or less cylindrical form. Of the latter, the chief forms are the BLAST FURNACE and the CUPOLA FURNACE. In the blast furnace (fig. 1) the body of the furnace is of brick or stone, often cased with wrought iron plates, or heavily hooped, and having an inner lining of firebrick, separated from the outer portion by a layer of sand or cinders. This forms a porous mass through which gases expelled from the brickwork can escape. The body is not truly cylindrical, but usually widens out in the centre, resembling in section a part of two cones placed base to base. The widest part B is termed the BELLY, the conical portion below the Belly is termed the BOSHES, while the part above B is termed the STACK. The part from L to K is termed the THROAT, and is surmounted by a TUNNEL HEAD (not shown in the sketch). The lowest part A is termed the HEARTH; here the molten metal collects, with the slag floating on top of it. The air or BLAST is forced into the furnace by jets C, termed TUYERES (*q.v.*), which enter the furnace some way above the hearth. Usually the jets are each surrounded by a water jacket, and are then termed WATER TUYERES. The object of the jacket is to cool the nozzle of the jet, and so prevent, as far as possible, its rapid destruction by the intense heat of the furnace, which may be over 1,500° C. In the SCOTCH TUYERE the nozzle is formed of wrought iron tube, coiled to form a truncated cone, enclosed in an iron casing, the cooling water circulating through the whole coil. There is an opening into the bottom of the furnace, leading out into a space F, called the FORE HEARTH; the latter is closed by a wall of firebrick D, termed the DAM, which is supported by a large casting E, the DAM PLATE. There is an opening in the top of the dam, termed the CINDER NOTCH, through which slag is withdrawn, and another in the bottom, termed the TAP HOLE, through which the molten iron can flow when required. This hole is, of course, closed during smelting until a sufficient amount of fluid iron has collected in the hearth. The charge of iron ore, coal, and flux is introduced into the furnace from a platform G running round the top, termed a CHARGING GALLERY, and it is caused to spread out by a large CONE H, which fits a cup or rim K round the mouth of the furnace. When the cone is lowered by a chain, a space is left through which the material can fall; when the cone is brought back into place, the mouth of the furnace is thereby closed, and the waste gases escape by means of large tubes LL. The heat carried away by these gases is utilised for heating the blast, and the gases themselves, consisting largely of carbon monoxide (CO), can be treated for the recovery of by-products and burnt as gaseous fuel. The CUPOLA FURNACE is very similar in principle to a blast furnace; its chief use is the melting of cast iron for the foundry. (2) Furnaces where the ore or metal is not in contact with the fuel. These may again be subdivided, according as the metal, etc.,

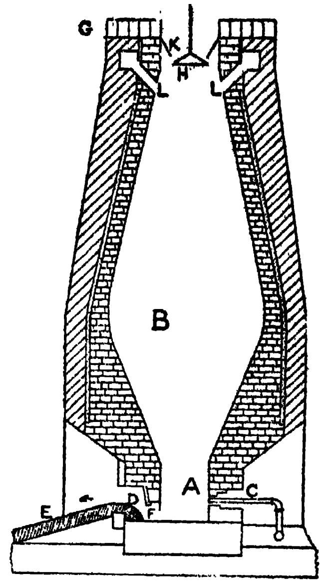


FIG. 1.—BLAST FURNACE.

is placed on a part of the hearth, but separated from the fuel, or placed in a special receptacle, such as a crucible, muffle, retort, etc. The first kind is usually a REVERBERATORY FURNACE (fig. 2). The hearth is divided into two areas, A and B, separated by a low wall of firebrick D, termed the FIRE BRIDGE. In the part A is the fire, in the other the metal or ore. The roof C of the furnace is so shaped as to deflect the flames from the fire down on to the ore, and thence onward to the flue. A PUDDLING FURNACE is of this type, and is used with natural draught (*q.v.*) in the conversion of cast into wrought iron by the operation of puddling (*q.v.*) Furnaces in which a special receptacle is used take a great variety of forms. In the simplest CRUCIBLE FURNACE or POT FURNACE a crucible is merely sunk into the mass of burning fuel contained in a furnace of any convenient shape. In RETORT FURNACES, used in the Belgian zinc process, the furnace is a vertical chamber, in which are fixed rows of closed retorts (*q.v.*) of fireclay. A MUFFLE FURNACE may be compared to an oven; it consists of a long flat-bottomed chamber of fireclay, surrounded by the fuel or hot gases, in which either crucibles or cupels (small shallow dishes of bone-ash or other material of an absorbent nature) can be placed. GAS FURNACES are used on a small scale in the laboratory; they consist of a fireclay body, into which project burners of the Bunsen type, producing a non-luminous flame of very great heating power. On a large scale gas furnaces are commonly worked by a cheap gas of very low illuminating power, such as DOWSON GAS, PRODUCER GAS, or MOND GAS (*q.v.*) In the REGENERATIVE FURNACES of Siemens and others the waste gases escape through a chamber filled with a mesh of brickwork, which very soon becomes heated. The waste gases are then turned off through another similar chamber or REGENERATOR, and the supply of unburnt gas or of air which supplies the furnace is allowed to enter through the first chamber. In this way a considerable amount of heat is utilised which would otherwise be wasted, and great economy of working is secured.

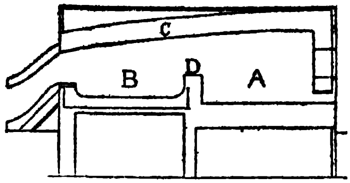


FIG. 2.—REVERBERATORY FURNACE.

Furniture (*Typog.*) The term furniture includes all those pieces of wood or metal that are used in making margin for the folding of books; for fastening the pages of type in the chase; or locking up forms when they are imposed. It is generally classed as reglet, furniture, sidesticks, footsticks, and quoins.

Furring *or* **Firring** (*Carp.*) Thin strips of wood, used to raise some part of a roof, floor, etc., slightly above the level of the timbers which carry the weight.

—— (*Eng., etc.*) The deposition of solid matter in pipes, boilers, etc. The solids are carried in the water (or other fluid) which flows through the pipes, either on suspension or in solution.

Furs (*Her.*) *See* HERALDRY.

Fuse (*Mining*). The device used for igniting a blasting charge. The old slow match and similar devices are now often replaced by an arrangement for producing an electric spark. The latter device renders the time of firing more certain, and is very much safer in case of a miss-fire.

Fusee (*Watches, Clocks*). A pulley of varying radius fixed to the arbor of the main wheel for the purpose of equalising the "moment" of the pull of the mainspring. A continuous groove cut in its surface from end to end carries the chain or cord. *See* GOING BARREL *and* MAINTAINING POWER.

Fusil (*Her.*) A subordinary, of lozenge shape, but of greater length than breadth.

Fusion (*Heat*). The melting of a solid, or the change from the solid to the liquid state.

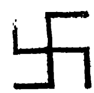
——, **Latent Heat of** (*Heat*). The amount of heat required to melt unit mass of a given solid without raising its temperature. The latent heat of fusion is given out when the body solidifies again, and may give rise to a marked increase in temperature, which is well shown in the common lecture experiment on the solidification of sodium sulphate.

Fustian (*Textile Manufac.*) A name for any class of grey cotton cloth of heavy make, having a weft pile surface which requires cutting, *e.g.* corduroys and velveteens.

Fustic. A yellow wood used in dyeing. It is obtained from the trunks of two trees: (1) *Chlorophora tinctoria* (order, *Moraceæ*); (2) *Rhus cotinus* (order, *Anacardiaceæ*).

Futures Cotton (*Cotton Trade*). A system of dealing by means of which a spinner may cover himself from loss when he has accepted a contract for spun yarn, and does not want to buy all his cotton at once. This legitimate system has been greatly abused by gambling transactions.

Fylfot (*Her.*) A mystic symbol said to be formed of four Γ's arranged in the shape of a cross; consequently called Gammadion. It has been extensively used as a decoration (perhaps a mystic symbol) in almost all parts of the world.



g (*Eng., Phys., etc.*) The letter "g" is used as a symbol for the acceleration produced by gravity; *i.e.* about 32·2 ft. per sec. per sec., or 981 cm. per sec. per sec. in England.

G (*Music*). The sixth note in the scale of C.

Ga. Chemical symbol for GALLIUM (*q.v.*)

Gab (*Eng.*) A notch, catch, hook, etc., in a lever which enables a temporary connection to be made between the lever and a projecting pin for actuating some piece of mechanism. The connection can be made or broken as required.

Gabbro (*Geol.*) A rock of eruptive origin which resembles granite in its structure, but consists of the same minerals as those forming basalt and dolerite. The constituent minerals are usually one of the lime soda felspars and one of the pyroxenes, together with titaniferous magnetite. Olivine is generally present. It is usually a rock of deep seated origin, and has, in most cases, been formed in the deeper part of the core of a volcano.

Gaberdine (*Cost.*) A long loose upper garment, much worn in the fourteenth century, and at a later date by shepherds, almsmen, and Jews.

Gable (*Architect.*) That form of roof termination in which the end wall is carried up vertically above the eaves to meet the ridge. Such an end wall is known as a Gable End.

Gab Lever (*Eng.*) A lever provided with a GAB (*q.v.*)

Gad (*Mining*). A wedge driven into a crack in a rock to split it.

Gadlings (*Armour*). Small spikes fixed to the knuckles of gauntlets. Worn during the fourteenth century.

Gagget (*Glass Manufac.*) A SPRING PONTY (*q.v.*)

Gait, Gaiting (*Textile Manufac.*) (1) The adjustment of a loom for weaving. (2) The space between two carriages when in working position on the machine.

Galactose (*Chem.*), $CH_2OH \, . \, (CHOH)_4CHO$. A white crystalline solid (hexagonal plates); melts at 163°; is soluble in water; has a sweet taste; reduces Fehling's solution about threequarters as strongly as dextrose; it is dextrorotatory. It is obtained by boiling milk sugar with dilute sulphuric acid, removing excess of acid by baryta, concentrating and adding a few crystals of dextrose, when galactose crystallises out, leaving the dextrose in solution. It has the general properties of the aldohexoses. *See* SUGARS. On reduction it yields dulcitol; on oxidation with bromine water it yields the monocarboxylic acid GALACTONIC ACID; on oxidation with nitric acid it yields the dicarboxylic acid MUCIC ACID.

Galaxy, The (*Astron.*) Another name for the Milky Way - the luminous belt of irregular width and outline which surrounds the heavens nearly in a great circle.

Galbanum (*Botany*). *Ferula galbaniflua* and *F. rubricaulis* (order, *Umbelliferæ*). A gum resin used in pharmacy, obtained from these and other species of *Ferula*.

Gale (*Meteorol.*) A wind blowing with great force, *i.e.* with a velocity of forty miles or more per hour. The word has no very exact or scientific meaning.

Galea (*Armour*). The Latin term for a helmet.

—— (*Botany, Zool., etc.*) Applied to various structures which either in shape or function serve as a helmet; *e.g.* the upper lip of a labiate flower; a horny cap on the head of a bird.

Galena (*Min.*) Lead sulphide, PbS. Lead = 86·6, sulphur = 13·4 per cent., with silver up to even 3 per cent. The silver probably exists as the isomorphous sulphide Argentite. Crystalline system cubic. More often it occurs massive in veins with barytes, quartz, calcite, zinc blende, fluorspar, etc. When fresh it is a brilliant metallic grey; almost black when weathered. It splinters on attempting to cut it with a knife. *Cf.* ARGENTITE. When the silver is over 8 to 12 oz. to the ton and worth extracting, it is called ARGENTIFEROUS GALENA, and the mines come under somewhat different conditions. If the trace of silver is left in the lead, it has rather more value for certain purposes. It is the chief ore of lead. From Cumberland, Westmoreland, Northumberland, Cornwall, Leadhills, Isle of Man, etc., and a great many places abroad.

Galilee (*Architect.*) A chapel, or a porch used as a chapel, usually built near the west end of a Gothic church. The galilee porch of Lincoln Cathedral is on the west side of the south transept.

Galileo (*Astron.*) The celebrated Italian astronomer who lived 1564—1642. He was the first to observe the heavenly bodies by means of the telescope.

Gall Bladder (*Zoology*). An outgrowth from the bile duct acting as a reservoir for the bile. It lies under cover of the lobes of the liver.

Galleïne. *See* DYES AND DYEING.

Galley (*Archæol.*) (1) A long low seagoing ship with one deck, at one time in common use in the Mediterranean. It was propelled by sails and oars, the rowers being generally slaves or criminals condemned to the galleys. They were frequently chained to the seats. (2) The term is also applied to Greek and Roman warships with one or more banks of oars. (3) A large open rowboat.

—— (*Typog.*) A flat piece of metal or wood with ledges on end and on one or two sides. It is used to receive type as composed.

Gallic Acid (*Chem.*),
$$\begin{array}{ccc} & C\,.\,COOH & \\ HC & & CH \\ HOC & & COH \\ & COH & \end{array} .$$
Silky needles; melts at 220°; not easily soluble in cold, readily in hot. water. It occurs in tea and some other plants. It is prepared from tannin (*q.v.*) by boiling with dilute sulphuric acid, or from gall nuts by maceration and allowing the cold liquid from the maceration to stand in air, when it ferments, forming gallic acid. When heated, gallic acid yields pyrogallol, $C_6H_3(OH)_3$ (*q.v.*) Ferric chloride gives a blue black precipitate. Its alkaline solution absorbs oxygen from the air and turns brown. On account of its power of reducing gold and silver salts to the metal, it is used in photography. The basic bismuth salt is used as a dry antiseptic under the name DERMATOL. Heated with strong sulphuric acid, it forms RUFIGALLIC ACID, a hexaoxy-anthraquinone.

Gallium (*Chem.*), Ga. *Atomic weight*, 70. A bluish white metal; melts at 30° to a silvery white liquid, which does not readily solidify again. The solid can be cut with a knife. It readily dissolves in hydrochloric acid or caustic soda solution. It is obtained by electrolysis of an alkaline solution of the sulphate. Gallium belongs to the aluminium group of metals, and forms an ammonium alum. The existence of this metal was predicted, and it was discovered by means of the spectroscope in zinc blendes from the Pyrenees, which contained less than sixteen parts per million.

Gallocyanine (*Chem.*),
$$\left.\begin{array}{r} HO \\ HO \\ HOOC \end{array}\right\rangle C_6H \left\langle\begin{array}{c} N \\ O \end{array}\right\rangle C_6H_3 : N \left\langle\begin{array}{l} OH \\ (CH_3)_2 \end{array}\right. .$$
Brilliant green needles, sparingly soluble in water. It is obtained by the action of nitrosodimethylaniline hydrochloride on gallic acid in hot alcoholic solution. It is an important dye, especially in calico printing, giving violet shades. *See* DYES AND DYEING.

Gallon. *See* WEIGHTS AND MEASURES.

Galloon. A close-woven braid composed of wool, cotton, or silk, combined with worsted; generally narrow. Used for trimming various articles of wearing apparel and on furniture. A kind of gold or silver lace, made of threads of gold or silver woven into a pattern; used on uniforms, etc.

—— (*Lace Manufac.*) When applied to lace means a double edged lace with well defined scallops.

Gallotannic Acid (*Chem.*) *See* TANNIN.

Galloway Boiler (*Eng.*) A form of Lancashire boiler provided with Galloway tubes. *See* BOILERS.

Galloway Tubes. *See* BOILERS.

Galls (*Botany*). Excrescences formed on the leaves of the oak by the Gall-wasp (*Cynips*). The insect punctures and deposits its eggs in the tissues of the leaf, and a poison introduced causes an excrescence to form.

Galmei (*Min.*) A synonyn for the silicate of zinc, HEMIMORPHITE (*q.v.*)

Galon (*Lace Manufac.*) *See* GALLOON.

Galton's Stove (*Build.*) The principle in this stove is the utilisation of heat which in the ordinary firegrates would be wasted. At the back of the grate an air chamber is constructed which is provided with two openings, one connected with the outer air and the other with the room. Air from without enters, and, being warmed by contact with the heated back and sides of the grate, rises up through a shaft which opens into the room between the mantelshelf and ceiling. All communication is cut off between the smoke flue and the air shaft. This principle is taken advantage of in constructing and fitting modern grates.

Galton's Whistle (*Phys.*) A sounding pipe, resembling in principle a very small closed organ pipe, producing a note of very high frequency. Used in experiments on the limits of audition.

Galvanised Iron (*Eng., etc.*) Sheet iron coated with zinc in order to prevent oxidation. The process is not electrical, as the name erroneously implies, but consists simply of dipping the iron into melted zinc. Under the influence of moisture and atmospheric impurities, the iron and zinc form an electric couple, and corrosion of the iron results. Pinholes, or small defects in the coating of zinc, facilitate this action.

Galvanometers (*Elect.*) A galvanometer is an instrument for detecting an electric current, or, within certain limits, for measuring its value. Practically all galvanometers depend for their action on the mutual effect of a magnet and an electric circuit, and they may be classified into two main groups. In the first or older form of galvanometer a small magnet is suspended or pivoted, so that it can turn freely inside a hollow coil of insulated wire which carries the current; in the second or more modern type, known as SUSPENDED COIL GALVANOMETERS, a small coil suspended so that it is free to turn between the poles of a powerful fixed magnet. The first group include the following forms: (1) The SIMPLE GALVANOSCOPE with a pivoted needle, controlled by the Earth's field (and therefore pointing N. and S. when at rest), and only suitable for detecting comparatively large currents. (2) ASTATIC GALVANOMETER, with two similar and nearly equal magnets rigidly fixed together parallel to each other, with their poles pointing in opposite directions. One needle is inside the coil of the instrument, the other is either outside or else in a second coil, in which the current flows in the opposite direction to the current in the first coil. As the two magnets are subject to opposite and nearly equal forces due to the Earth's magnetism, the controlling effect of the latter is very small, and the instrument is very sensitive, *i.e.* it turns with a very minute current. A SINE GALVANOMETER is one in which the coil itself can be rotated (by hand) about the same axis as that about which the needle turns; it is provided with a horizontal scale by means of which the angle through which the coil has been turned can be measured. The coil is first placed so that the plane of its windings lies in the magnetic meridian. The current is then passed, and the coil rotated in the same direction as the needle until the latter again lies in the same plane as the needle, and the angle through which it has been turned from its original position in the magnetic meridian is read. The amount of the current is proportional to the sine of this angle, *i.e.* $C = k \sin \theta$. A single observation on a current of known value gives the value of the constant k. A TANGENT GALVANOMETER is one with a coil of large diameter, usually wound on a hoop of wood or brass. In the centre of this hoop is suspended (or pivoted) a short magnetic needle, which is usually provided with a long pointer moving over a fixed scale, by means of which the deflection of the needle may be observed. The coil is set in the plane of the magnetic meridian; the current is then proportional to the *tangent* of the angle of deflection, or $C = K \tan \theta$. The constant K is termed the REDUCTION FACTOR of the instrument. It may be found by means of an observation of the deflection produced by a known current, or it may be calculated from a knowledge of the size and number of turns of wire on the coil, if the local value of the Earth's horizontal magnetic force be known. If the average radius of the various turns of wire constituting the coil be r, and the number of turns be n, and H be the horizontal magnetic force, θ the deflection produced by a current whose amount in absolute units is C, then $C = H \frac{r}{2\pi n} \tan \theta$. The quantity $\frac{2\pi n}{r}$ is often denoted by G, and is known as the GALVANOMETER CONSTANT. Thus the Reduction Factor is equal to the horizontal magnetic force, divided by the galvanometer constant, or $K = \frac{H}{G}$. In all the above galvanometers a small deflection can only be detected by fitting a long pointer, which adds considerably to the mass (or, rather, to the Moment of Inertia) of the suspended magnet, and reduces its sensitiveness. To overcome this difficulty, the REFLECTING or MIRROR GALVANOMETER is used. This possesses a small magnet fixed to a very light mirror. The system is suspended inside the coil of the instrument by a fine fibre of unspun silk or of quartz. *See* QUARTZ FIBRES. The deflection may be observed in two ways: in the system commonly used in England a beam of light is thrown by means of a lamp and a suitable lens on the mirror, and reflected by it so as to fall on a divided scale. The beam of light then serves as a weightless pointer, whose length may be increased at will without affecting the mass of the moving parts. In the second method, which is the one most used in Germany, a reading telescope is focussed on the mirror; a divided scale is fixed in a horizontal position just above or just below the object glass of the telescope, and the image of its divisions can be seen reflected in the mirror. As the latter turns, successive divisions are brought into view, and the amount of the deflection can be read. It should be noted that the beam of light turns through *twice* the angle of deflection of the mirror. A mirror galvanometer is usually fitted with a CONTROLLING MAGNET, which is attached, with its axis

horizontal, to a vertical rod projecting from the top of the instrument. By turning this magnet, the galvanometer needle may be brought to rest in any convenient position, independent of the magnetic meridian. By raising or lowering the magnet, the sensitiveness of the galvanometer may be increased or diminished. The sensitiveness of a galvanometer may be increased by using a very large number of turns of wire on the coil, by diminishing the radius of the coil, and by making the suspended system as light as possible. In this way instruments have been constructed which are capable of detecting a current of 10^{-13} ampères, a current so small that it would require centuries to liberate a cubic centimetre of hydrogen (J. J. THOMSON). The second group, the SUSPENDED COIL GALVANOMETERS, possess a powerful fixed magnet, bent into a horseshoe shape, so that its poles are close together. In the gap between the poles a coil of fine insulated wire is suspended by a very thin flat strip or a fine wire, which serves to conduct the current from one terminal of the instrument to the coil. The circuit is completed either by a second suspending wire alongside the first (thus forming a bifilar suspension) or else by a wire or helical spring running from the lowest point of the coil to a conductor fixed on the base of the instrument. This class of instrument are often termed D'ARSONVAL GALVANOMETERS. They are unaffected by the Earth's magnetism or any other external magnetic field; they can be made practically dead beat (*vide infra*), and can be constructed to work in various positions. The following definitions apply to both classes of galvanometers alike: An APERIODIC or DEAD BEAT galvanometer is one in which the suspended system (needle or coil) is prevented from swinging backwards and forwards after the current has either ceased or become steady. The checking of the motion is termed DAMPING; it may be effected by mechanical or by electrical means. The best method, applicable to the D'Arsonval type, is to wind the coil on a metal frame or enclose it in a metal tube (Ayrton and Mather's method). As this frame or tube oscillates in the magnetic field between the poles of the magnet, currents are induced in the metal which tend to bring it to rest (*see* LENZ'S LAW). A BALLISTIC GALVANOMETER is one in which the damping is very slight; it usually possesses a comparatively heavy needle. It is used for measuring the transient currents produced when a quantity of electricity is discharged through the instrument. The sine of half the angle of the first swing is proportional to the total quantity of electricity which has passed through the coil. The exact expression for this quantity is $Q = \frac{HT}{\pi G} \sin \frac{\theta}{2}$, in which Q is the quantity of electricity, H the strength of the Earth's field (or, more generally, of the controlling force, which may not be due to the Earth's field), T the time of swing of the needle, G the galvanometer constant, and θ the angle through which the needle swings. The degree of sensitiveness, or FIGURE OF MERIT, of any galvanometer is determined by the amount of current required to deflect the needle (or spot of light) through one division of the scale. In a reflecting galvanometer this will depend upon the distance between the mirror and scale.

Gambeson (*Armour*). A tunic of thick cloth or leather, worn in the thirteenth and fourteenth centuries as a defence, or under the habergeon or hauberk to prevent chafing.

Gamboge. A gum resin derived from a tree (*Garcinia*; order, *Guttiferæ*) which grows extensively in Siam and Ceylon. It is usually imported in the form of sticks or cylinders, but sometimes in cakes or lumps. The resin is soluble in ether, alcohol, and water. It gives a bright yellow colour, and is employed as a water colour, but is not permanent, *i.e.* is bleached by the sunlight. It is not much used ground in oil, but is useful as a bright transparent glaze. It is employed somewhat extensively for colouring yellow spirit varnishes and golden lacquers. Analysis shows gamboge to consist of about 3 parts resin and 1 part gum.

Ganglion (*Zoology*). A group of nerve cells occurring in connection with nerves.

Gangue (*Mining*). A term for the matrix which encloses the ore within a metalliferous vein. It may consist wholly or in part of broken pieces of the country rock, or it may be mixed in variable proportions with any of the vein minerals, such as quartz, barytes, fluorspar, calcite, limonite, etc.

Gangway (*Mining*). A general name for a passage.

Gannister (*Geol.*) A compact and usually fine grained sandstone consisting of nearly pure quartz grains cemented by a siliceous matrix. It is, in fact, a variety of quartzite (*q.v.*) which occurs in connection with some few coal seams. It is of considerable commercial value as a constituent of the refractory materials used for lining iron furnaces and other chambers exposed to a very high temperature.

Gantrees (*Cotton Manufac.*) Beams or girders to support Jacquard machines over power looms.

Gantry (*Build.*) A stage built over the pavement to work on; foot passengers pass underneath.

—— (*Eng.*) The frame which carries the mechanism of an overhead crane.

Gap Bed (*Eng.*) A lathe bed having an opening near the headstock to admit an object of larger diameter (*e.g.* a wheel) than the actual distance between the line of centres and the surface of the bed. When not in use the gap can be filled by a casting termed the BRIDGE or GAP BRIDGE, whose upper surface is similar in form to, and continuous with, the lathe bed.

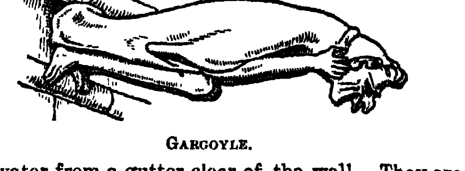
Gap Bridge (*Eng.*) *See* GAP BED.

Gap Lathe (*Eng.*) A lathe with a GAP BED (*q.v.*)

Garage (*Motor Cars*). A depôt for the storage or (storage and repair) of motor cars.

Garden Wall Bond (*Build.*) A method of bonding 9 in. walls, one header to every third or fourth stretcher.

Gargoyle *or* **Gurgoyle** (*Architect.*) A spout projecting from the face of a building and throwing



GARGOYLE.

the water from a gutter clear of the wall. They are sometimes quite plain, but more usually grotesquely carved.

Garnet (*Min.*) This name is applied to a group of minerals, all of which consist of anhydrous silicates, crystallising in forms of the cubic system. The following are the more important:

(1) Calcium Aluminium Garnet . ($Ca_6Si_3O_{12} . Al_4Si_3O_{12}$)
(2) Magnesium Aluminium Garnet ($Mg_6Si_3O_{12} . Al_4Si_3O_{12}$)
) Iron Aluminium Garnet . . ($Fe_6Si_3O_{12} . Al_4Si_3O_{12}$)
) Manganese Aluminium Garnet ($Mn_6Si_3O_{12} . Al_4Si_3O_{12}$)
) Calcium Iron Garnet . . . . ($Ca_6Si_3O_{12} . Fe_4Si_3O_{12}$)
) Calcium Chromium Garnet . ($Ca_6Si_3O_{12} . Cr_4Si_3O_{12}$)

Garnierite (*Min.*) A hydrous nickel magnesium silicate, containing approximately 30 per cent. of nickel oxide. It is an amorphous mineral, apple green to white in colour, occurring in considerable quantity in veins in serpentine in New Caledonia. Also found in the United States.

Garter, Order of. The Order of Chivalry instituted by Edward III., one of the most famous in the world. The emblem is a blue ribbon bearing the motto, "Honi soit qui mal y pense," in gold letters. It is always represented as part of the Royal Arms, and surrounds the shield. Members of the Order also wear other insignia, including a collar with the "George," the star, the mantle, and the ribbon of blue, to which is attached the "Badge" or "Lesser George." Knights of the Garter place after their names the letters K.G., which takes precedence of all other titles.

Garth (*Architect.*) An enclosed space, such as the quadrangle enclosed by the cloisters. *See* CLOISTERS.

Gas (*Phys., etc.*) A gas is a fluid which, when introduced into any given vessel, expands and fills the vessel. It has no finite surface or volume of its own, both being determined by the surface and volume of the vessel in which it is contained.

Gas Barrel. The wrought iron tube used for conducting gas from the large mains (usually of cast iron) into buildings, and up to the point from which it is distributed by "compo" pipes (an alloy of lead).

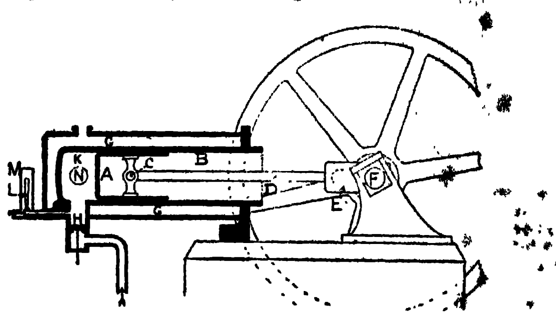
Gas Carbon (*Chem.*) A dense form of nearly pure carbon found lining the retorts in coal gas making, sometimes called artificial graphite. It is used in making the carbon electrodes in arc lamps, and in making the carbon poles of Bunsen and other primary cells.

Gas Coke. The ordinary coke resulting from the distillation of coal in gas works. Distinguished in the arts and trades from coke which has been prepared in ovens for special use in metallurgical or other operations, which is usually much harder and denser than gas coke. *See* COKE.

Gas Cylinders (*Lantern Work*). Compressed gases are sent out in steel cylinders, whose capacity is given by the number of cubic feet of gas measured at atmospheric pressure, which can be pumped into them without the pressure rising to a dangerous amount. A 40 ft. cylinder is about 32 in. long and 5½ in. diameter. The mouth is fitted with a valve opened and closed by a strong screw.

Gas, Dissociation of. The splitting up of a complex molecule of a gas into simpler molecules or into single atoms.

Gas Engines. The term Gas Engine is often used as a synonym for an INTERNAL COMBUSTION ENGINE, *i.e.* one in which the energy is obtained by the combustion or explosion of a gaseous charge, mixed with air, in the cylinder of the engine itself. It is more correct, however, to confine the term to those engines which are supplied with gas manufactured by separate plant, as distinguished from oil and petrol engines (*q.v.*) A somewhat diagrammatic representation of a typical gas engine (Crossley's) is given in the figure. A is a piston (of the TRUNK



GAS ENGINE.

or tubular form) working in a cylinder B, and attached by a pin at C to a connecting rod D. The connecting rod actuates a crank E, and drives the main shaft F, on which is the flywheel of the engine. The cylinder is surrounded by a water jacket GG, through which a current of cold water flows, in order to prevent the cylinder from becoming overheated. The ADMISSION VALVE H is opened by the valve gear at the commencement of a cycle (*vide infra*), just as the piston commences to move from left to right. A mixture of gas and air is drawn into the cylinder during the stroke; at the end of the stroke, H is closed, and the piston, as it returns, compresses the mixture of gas and air in the space K, which is termed the CLEARANCE SPACE, COMPRESSION CHAMBER, or IGNITION CHAMBER. The mixture is then ignited (caused to explode) by the opening of a timing valve, which allows a portion of the gas to flow into an IGNITION TUBE L. This tube is maintained at a red heat by means of a burner in the outer tube M. The explosion of the gas in the cylinder drives the piston forward again, thus performing useful work, a portion of which is stored up in the flywheel, and serves to keep the engine running during the remainder of the cycle. The completion of the series of operations is effected by the opening of an exhaust port N; the return stroke drives out the burnt gases, and when this operation is complete N closes, H opens, and a fresh cycle begins. The valves are generally worked by means of a subsidiary LAY SHAFT driven from the main shaft F by bevel gearing; suitable cams and levers connected to this shaft actuate all three valves; *viz.* H, N, and the TIMING VALVE, which controls the ignition. This complete CYCLE or series of operations occupies two revolutions of the engine or four strokes of the piston; it is termed the OTTO CYCLE. The engine has only one working stroke out of four, or one impulse in two revolutions, and the action of the engine will be very unsteady unless a very heavy flywheel be employed. For this reason modifications of the simple type described above are now made. One class of gas engines is made double acting, so that an explosion occurs on each side of the piston alternately. In another form, often termed TWO-STROKE or (incorrectly) TWO-CYCLE engines, the charge is forced into the cylinder before the end of the exhaust stroke by means of a separate or DISPLACER PUMP. The compression is completed in the cylinder

by the main piston, and the ignition and working stroke follow as in the OTTO CYCLE. The main piston may serve as a displacer, drawing the charge into the front end of the cylinder or into a CRANK CHAMBER, an enclosed space containing the piston, connecting rod, and crank, and provided with air-tight bearings for the crank shaft and with a suitable valve for the admission of the gas and air. In this space the charge is compressed sufficiently to force it into the main cylinder, just before the end of the return or exhaust stroke, as above described. The fresh charge serves to expel the exhaust gases; the exhaust port then closes, and compression occurs. This two-stroke cycle has been applied both to large and small engines, and especially to small petrol engines (*q.v.*) The changes in pressure and volume which occur in the cylinder of a gas engine are well shown by its INDICATOR DIAGRAM (*q.v.*) The methods of igniting the charge, which are to a large extent common to all classes of internal combustion engines, are dealt with under IGNITION (*q.v.*) *See also* OIL ENGINES *and* PETROL ENGINES. The theoretical efficiency of a gas engine (*see* EFFICIENCY OF HEAT ENGINES) is much higher than that of a steam engine; this is due to the very high temperature attained by the gases after the explosion. This efficiency may be as high as ·7 or ·8; the practical efficiency is less than one-third of this. But owing to the high theoretical efficiency, it is more economical (*i.e.* more work is obtained) to turn fuel (coal or oil) into gas, and use it to drive a gas engine, than to use the fuel either in the solid or liquid form to produce steam for a steam engine. On this account the use of gas engines is largely increasing, especially in cases where a cheap form of gas, such as MOND GAS (*q.v.*), can be obtained.

Gaseous Fuel (*Eng.*) Coal gas is employed to heat very small furnaces. On a larger scale, PRODUCER GAS (*q.v.*) is used on account of its much greater cheapness. *See* FURNACES.

Gaseous Steam (*Eng.*) Steam which has been heated to above its saturation temperature, *i.e.* SUPERHEATED STEAM (*q.v.*)

Gases, Density of (*Phys.*) *See* DENSITY OF GASES.

——, **Diffusion of** (*Phys.*) *See* DIFFUSION.

——, **Expansion of** (*Phys.*) *See* EXPANSION.

——, **Kinetic Theory of** (*Phys.*) *See* KINETIC THEORY OF GASES.

——, **Liquefaction of** (*Phys.*) *See* LIQUEFACTION OF GASES.

——, **Velocity of Sound in** (*Phys.*) *See* VELOCITY OF SOUND IN GASES.

Gas Governors. *See* GAS REGULATORS.

Gasket (*Eng.*) Rope or yarn plaited together and used with grease for filling or packing the stuffing boxes (*q.v.*) of engines. Also metal packings of various materials used in fixing boiler fittings to the boiler shell on surfaces which cannot be "faced.' Gaskets of fine brass wire (set in red-lead putty); corrugated copper (most serviceable for large joints which have to be taken apart periodically); hard rubber; or sometimes merely copper wire or small lead pipe laid in a groove on the flange, are among those most commonly employed.

—— (*Plumb.*) In plumbers' work tow (gasket) is packed round the spigot in the socket of an iron pipe before the lead is run in.

Gas Liquor (*Chem.*) When coal is dry distilled, as in coal gas making, there are produced liquid as well as gaseous products. The liquid products separate into two layers: the lower layer is coal tar and the upper layer is a watery liquid containing compounds of ammonia. To the watery liquid is added the water used in washing the coal gas free from ammonia: the whole is what is called gas liquor. It contains a large number of ammonia compounds, chief among which are the carbonate, chloride, sulphide, thiosulphate, and cyanide. Gas liquor is the chief source of ammonia and its compounds. *See also* GAS MANUFACTURE.

Gas Manufacture. The distillation of coal, as carried on in gasworks, gives rise to three main products: A. COAL GAS: B. COAL TAR; C. AMMONIACAL *or* GAS LIQUOR. Each of these is a very complex mixture of various substances, and the two latter serve as the raw material for the preparation of a very large number of organic substances. The actual processes, as carried on in the gasworks, are described here.

A. COAL GAS.—Coal of suitable character is heated to a red heat in tubular chambers of fireclay, known as RETORTS, from which iron pipes serve to convey the gaseous products to the CONDENSING APPARATUS. The end of the pipe from each retort is bent over, forming a DIP PIPE, which dips from 1 to 3 in. into water contained in a large horizontal tube, termed the HYDRAULIC MAIN. The more volatile products condense in this main, and are drawn off into a receptacle called the TAR WELL. The gas now passes through a series of vertical tubes exposed to the cooling action of the air. This apparatus is called an ATMOSPHERIC CONDENSER. The lower ends of the tubes dip into water, in which more of the volatile constituents (chiefly tarry) condense as the gas gradually cools down. Up to this point the gas has been kept at a pressure less than that of the atmosphere by means of exhausting pumps; but after passing the condensers it is forced through the remaining parts of the apparatus under pressure. The next step is to remove ammonia and other soluble gases by subjecting the gas to the action of numerous finely divided streams of water in WASHERS or SCRUBBERS. These were originally tall iron cylinders filled with coke, through which water trickled slowly. Scrubbers are now much more frequently filled with boards, about a foot broad and a quarter of an inch thick, placed on edge, about threequarters of an inch apart, each one being placed at a different angle from the one above it. This pattern of scrubber is far more effective than the old pattern, which became choked with tar, in which condition it lowered the illuminating power of the gas. On leaving the scrubbers, the gas has lost most of its tar and ammonia compounds; but it still contains carbon dioxide and various sulphur compounds, which must be removed. This is done by passing the gas through PURIFIERS, which are shallow perforated trays or sieves filled with moist lime, hydrated ferric oxide, and sometimes Weldon mud (*q.v.*) The process of purification varies considerably in different works, the main point being to reduce the impurities to a certain amount fixed by law, and at the same time to secure the sulphur, etc., in the form of a useful by-product. The lime in the purifiers absorbs the carbon dioxide and sulphuretted hydrogen, forming calcium carbonate and calcium sulphide. As the lime has a greater affinity for the carbon dioxide, the sulphuretted

hydrogen is gradually expelled, passing on to the next box. Calcium sulphide (free from the carbonate) is thus formed, and this arrests the carbon bisulphide, CS_2, in accordance with the equation $CaS + CS_2 = CaCS_3$. The process is still further accelerated by the introduction of a small percentage of oxygen. After leaving the purifiers, the gas passes into GASHOLDERS, in which it is stored under suitable pressure ready for distribution. The composition of coal gas is variable; an average specimen might contain, approximately, hydrogen, 50 per cent.; marsh gas, 33 per cent.; carbon monoxide, 10 per cent.; olefines, 4 per cent.; oxygen, nitrogen, carbon dioxide, sulphuretted hydrogen, etc., 3 per cent. If the ILLUMINATING POWER (*q.v.*) is too low, the gas must be enriched; this is done by the addition of OIL GAS, obtained by heating a heavy hydrocarbon oil, usually a PARAFFIN (*q.v.*), of density ·8 to ·9, or by the addition of ACETYLENE (*q.v.*) By this means the illuminating power is brought up to the standard fixed by law. This is usually fixed at such a value that a burner of specified form, when consuming 5 cubic feet of gas per hour, shall give a light of sixteen candle power.

B. COAL TAR DISTILLATION.—The crude or raw material for this industry is furnished by the gas-works, and is known as gas tar. The constituents of this substance escape from the retorts, and are condensed in the hydraulic mains, condensers, and scrubbers. It collects in large vessels called tar wells, and is either reserved for subsequent treatment by the gas company, or else, as is more usually the case, it is sold to the tar distiller. In its crude condition gas tar always contains a certain quantity of ammoniacal liquor (gas liquor), from which it must be freed before it undergoes distillation. This preliminary dehydration (as it is called) takes place in large wrought iron vessels provided with a dome top. Below the dome roof, but near the top of the vessel, there is fitted a small overflow pipe and cock. When the first charge of tar is run in, the vessel is "fired" from below. As the temperature inside rises, the tar becomes thinner and its bulk becomes greater. The contained water in it gradually rises to the surface and accumulates there. It is then gradually drawn off by means of the overflow pipe mentioned above. When all the contained water has thus been drawn off, the tar, having a greater specific gravity, remains behind in the still. In addition to an overflow pipe, there is fitted near the bottom of the still an exit pipe, also fitted with a cock. This serves to run off the pitch when the whole process of the distillation of the charge has been performed. The gaseous products of distillation (hydrocarbons) are carried away by a pipe leading to a condenser. This consists essentially of a coil or worm immersed in water in a cylindrical vessel. The pipe through which the gases escape leaves the still at the top of the dome, and is, at the commencement, of considerable diameter (about 12 in.), which, however, rapidly diminishes to about 6 in. It makes a sharp turn in its direction at this point, being bent almost at right angles. In addition to this tube, the still is provided with a manhole and safety plug fitted on to the dome roof. The principle which underlies the method of tar distillation is that known as "fractional distillation." It consists in the separate collection of various groups of volatile oils by taking advantage of the fact that between two given temperatures a particular group or family of compounds will pass over from the still, thus permitting a preliminary classification. These compounds undergo condensation as they pass through the condenser, and subsequently flow into a "receiver." The usual classification of these compounds adopted in practice is: I. Crude and light oils, distilled up to 170°; II. Crude carbolic (phenol), distilled up to between 170 and 230°; III. Heavy creosote oils, distilled up to between 230 and 270°; IV. Anthracene oil, distilled up to over 270°; V. Pitch, residue in tar still. I. CRUDE AND LIGHT OILS (average specific gravity about ·98): These contain a variety of substances, and in order to effect their separation, a further process of distillation takes place. During this redistillation, whilst the temperature is between 80 and 110°, two important compounds are driven off. These are known as BENZENE and TOLUENE, and form the basis from which the commercial products known as "90 per cent. BENZOL" and TOLUOL are prepared. The liquid which is collected in the receiver during distillation between 140 and 170° is commonly known as SOLVENT NAPHTHA. II. CARBOLIC OILS: These are heavier than the preceding group, possessing an average specific gravity of 1·003. The two most important compounds derived at this stage are: (*a*) NAPHTHALENE, (*b*) CARBOLIC ACID. (*a*) NAPHTHALENE: This substance crystallises out on cooling in large colourless crystals. It is drained and pressed to squeeze out any adhering carbolic. It is then agitated with concentrated sulphuric acid, and subsequently with caustic soda. The caustic alkali dissolves any carbolic acid that may have been retained by the naphthalene. This latter then undergoes a final distillation or sublimation. When pure, it is often sold as a white solid substance, known variously as "pure candle naphthalene," "albo carbon," or simply as "carbon," which is merely a trade name, as it is a complex hydrocarbon. (*b*) CARBOLIC ACID: This compound, having been dissolved in the caustic soda solution, is recovered by neutralising with H_2SO_4, upon which the carbolic acid separates out as an oily liquid. This oil is then washed with water and is redistilled. It is usually prepared for the market either as "carbolic acid crystals" (pure) or as "liquid carbolic acid" (impure). Its great value lies in its properties as a disinfectant and antiseptic. III. HEAVY CREOSOTE OILS: These are distilled over, and collected at temperatures ranging from 230 to 270°. As these oils become free from the presence of crude carbolic acid, they are characterised by an oily, greasy nature, and possess lubricating properties of a somewhat inferior kind. The colour is usually a yellowish green. Creosote oils may be considered as consisting of two main portions: the first, known as "liquid creosote" (yellow creosote), and the second, a greenish grease or oil. Liquid creosote is used as a liquid fuel and for illuminating purposes. The ordinary creosote is largely used for "pickling" railway sleepers. *See* CREOSOTING. Creosote contains about 40 per cent. crude naphthalene (creosote salts). These salts separate out from the oil, and are deposited in very large quantities at the bottom of the storage tanks in which the liquid is run for storage and cooling. After cooling, the crude creosote salts can be shovelled out and allowed to drain. These salts have a ready sale, as the raw material for refined naphthalenes. IV. ANTHRACENE OIL: These bodies are collected at temperatures of 270° and upwards. They may be regarded as hydrocarbons which are solid at ordinary temperatures. They are separated from the liquid hydrocarbons associated with it by treatment in filter presses or hydraulic presses, after

cooling. This process extracts the green anthracene oil. The crude anthracene contains about 30 per cent. pure anthracene. It is either sold as such or undergoes further purification, such as washing with solvent naphtha, to free it from its impurities. This yields an anthracene of 50 per cent. or even higher. Anthracene may be regarded as one of the most important products of tar distillation, owing to the fact that ALIZARINE—so important in the manufacture of dyes—can be synthesised from it. V. PITCH: This is the final residue remaining in the still after one complete cycle of operations. At the last stage of distillation superheated steam is driven into the still. This serves to sweep out any vapours still remaining, and helps to break up the hard crust on the bottom of the still, thus preventing "coking" of the pitch. The pitch is then run off from the exit pipe whilst still hot and liquid into the "pitch cooler." It remains in this closed chamber for an interval of six to twelve hours, until it ceases to give off vapours. When in no danger of taking fire in the open air, it is allowed to flow off from the cooler into the pitch bed, where it is allowed to solidify into a hard, brittle, black mass, not unlike cannel coal in appearance. From here it is hacked and hewed out as required for despatch by barge, truck, or ship. It commands an enormous sale on the Continent, as a "binder" in the manufacture of the "patent fuel" so largely used for locomotive and railway purposes (briquettes). It is also made into "asphalt" by mixing with creosote oil and sand, gravel, or stone chips. It may be added here that the distillation of one ton of gas coal will yield on an average from ten to eleven gallons of tar, from which about eighty pounds coal tar pitch can be produced.

C. BY-PRODUCTS FROM AMMONIACAL OR GAS LIQUOR.—In addition to the large number of useful commercial substances which are obtained by the distillation of coal tar derived from the manufacture of coal gas (*see* COAL TAR DISTILLATION), there is another large and important body of compounds of which AMMONIACAL LIQUOR is the chief source. Ammoniacal liquor (known also as GAS LIQUOR or MOTHER LIQUOR) is formed in the condensers and the scrubbers (*see above*). Ammoniacal liquor is a highly complex aggregate of compounds, in each of which the ammonia plays the part of base. It contains CARBONATES, SULPHIDES, CYANIDES, THIOCARBONATES, THIOSULPHATES, SULPHOCYANIDES, and FERROCYANIDES OF AMMONIA, along with some free ammonia. The first three compounds enumerated along with the free ammonia are removable by boiling, being volatile at ordinary temperatures. The others or FIXED ammonia compounds are removable on boiling with milk of lime. The most valuable commercial products obtained from gas liquor are: (1) Sulphate of Ammonia; (2) Ferrocyanides. Owing to the valuable properties that sulphate of ammonia possesses as an artificial manure, its manufacture is a source of profit to gas companies and corporations. It is by no means unusual to erect a sulphate plant as one of the adjuncts of a gasworks. Sulphate of ammonia contains of nitrogen about 20 per cent. of its weight, and is therefore richer in that element than its chief rival, nitrate of soda, which contains about 16 per cent. of its weight of nitrogen. SULPHATE OF AMMONIA MANUFACTURE: The sulphuric acid which is necessary for the manufacture of this important "residual" is usually derived from the spent oxides of iron from the PURIFIERS of gasworks, or it may be produced from iron pyrites, which is imported in large quantities from Spain and Scandinavia for that purpose. Both these raw materials contain the necessary sulphur—as much as 50 per cent. by weight. *See* SULPHURIC ACID. In the manufacture of sulphate of ammonia the ammoniacal liquor, after being boiled with lime in "lime boilers," is thus freed from its combined ammonia gas. The sulphuric acid is then saturated with ammonia gas in the "saturators." The ammonia is thus converted into sulphate of ammonia. On crystallising out from this concentrated solution, the salt is freed from water by dehydration in CENTRIFUGAL DRYING MACHINES. It is sold as yellow or grey salt, and contains about 25 per cent. of ammonia. FERROCYANIDES AND CYANIDES FROM GAS LIQUOR: These may, along with sulphate of ammonia, be regarded as the two most valuable products recoverable by gasworks from their crude gas liquor. The existence of the cyanogen (CN) radicle in gas liquor has long been known, but it has only been during the last ten years that gasworks have been considered an important source of these compounds. The enormous success which has attended the McArthur Forrest process (in South Africa and elsewhere) for the recovery of gold from "slimes" or "mill tailings" by treatment with a solution of cyanide of potassium has consequently directed much attention to these products during recent years. The principle of the process carried on by several of the largest gasworks in the United Kingdom and on the Continent is the elimination of the cyanogen contained in the gas by forcing the latter to pass through a special mechanical "washer" before entering the purifier. This washer is an apparatus divided into four or five compartments, the last compartment containing a concentrated solution of an iron salt (preferably copperas = sulphate of iron). After forcing the gas through this apparatus for some hours, the SULPHATE of iron is reduced to SULPHIDE of iron, and the ammonia of the gas combines with the acid to form sulphate of ammonia. The sulphide of iron is then attacked by the ammonia and cyanogen of the gas, and is converted into an insoluble double salt, ammonium ferrocyanide. The gas is thus freed from its cyanogen, which remains behind in the liquor. This liquor is of a colour ranging from black to yellowish green, and of a muddy consistency ("cyanogen liquor"). This sludge, or muddy liquor, is boiled until its ammonia is driven off. The insoluble residue, consisting of the double salt of iron and AmCN, is then compressed in filter presses to a CAKE, which contains about 30 per cent. of Prussian blue. Yellow prussiate of potash is prepared from this by fusing with carbonate of potash. Cyanide of potassium (for gold extraction) is prepared by heating prussiate of potash, carbonate of potash, and metallic sodium together in iron crucibles. It should be added that the enormous demand for cyanide of potassium has, during the last few years, led to the perfecting and patenting of many ingenious processes for its manufacture by other means than from the ferrocyanide of gas liquor. These "synthetical" processes aim at the production of alkaline cyanides (chiefly sodium cyanide) by the direct combination of ammonia (giving nascent nitrogen) with carbon in the presence of an alkali metal. Another ingenious method is based upon the removal of sulphur from sulphocyanides by oxidation of the sulphur to SO_2 with nitric acid. The gasworks, however, possess a very valuable source of cyanogen in their liquors, which is readily and cheaply converted into prussiate of potash, to such

an extent that, at the present moment, the cyanide market is suffering from over production.

Gas, Natural (*Geol.*) A native hydrocarbon in a gaseous state which is liberated, usually by artificial means, such as boreholes, etc., from subterranean reservoirs, which occur in various parts of the world. These are commonly associated with deposits of gypsum, anhydrite, rock salt, or some of the minerals which accompany these.

Gasoline (*Chem.*) A low boiling fraction (70° to 90° C.) of American petroleum; used as a solvent and for increasing the illuminating power of coal gas.

Gasoline Engines. PETROL ENGINES (*q.v.*)

Gas Pliers. Strong pliers with curved and toothed jaws in which gaspipe can be held.

Gas Ports (*Eng.*) Apertures in a gas engine cylinder for the admission of the charge of gas.

Gas Producer (*Eng., etc.*) A form of furnace, charged with coke and inferior carbonaceous fuel, through which is blown air and steam. A mixture of hydrogen, oxygen, carbon monoxide, and certain non-combustible gases is formed, known as PRODUCER GAS (*q.v.*) This gas can be burnt, giving a very economical fuel for furnaces and boilers, or it can be used to drive gas engines after it has been purified by simple processes resembling those employed in gas manufacture (*q.v.*)

Gas Pump (*Eng.*) A small pump used in some forms of gas engine for compressing the charge and forcing it into the cylinder.

Gas Regulator (*Lantern Work*). An automatic valve governed by a spring which controls the supply of gas from a gas cylinder: this valve permits a steady flow of gas at a very constant pressure, and the main valve of the gas cylinder need not be touched after it has once been opened, until the supply is no longer required; any necessary regulation of the amount of gas may be done by means of the small taps attached to the oxyhydrogen jet.

—— (*Plumb.*) Special forms of float valve are used as regulators or governors on the service pipes of large institutions to regulate the pressure. They ensure a steady light at the burners, and save waste by flaring.

Gassing (*Chem. Eng.*) A term applied to the poisoning of workmen by sewer and other gases escaping from chemical plant, notably H_2S, N_2O_4, CO, AsH_3, etc. Special rules are now approved by the Home Office for the prevention and treatment of such cases. The remedies are much the same as for cases of drowning, *e.g.* artificial respiration, the use of compressed oxygen, etc.

—— (*Textile Manufac.*) A process for clearing the spun thread of loose fibres or fluff by passing quickly through a gas flame and singeing; this imparts a smooth surface to lace, yarns, etc. *See also* SINGEING.

Gas Stocks and Dies (*Eng.*) Appliances for cutting gas-threads, *i.e.* the fine screw thread used in connecting pieces of iron gas barrel.

Gas Stoves. *See* STOVES.

Gas Tar. *See under* GAS MANUFACTURE.

Gas Thermometers. *See* THERMOMETERS *and* MEASUREMENT OF TEMPERATURE.

Gas Threads. *See* SCREW THREADS.

Gastric Juice. The stomach secretion of animals: in man it may be said to consist of the ferment pepsin (an enzyme), hydrochloric acid, and the chlorides and phosphates of sodium, potassium, ammonium, calcium, magnesium, and iron—all present in very small quantity: water forms 90·5 per cent. of the gastric juice. It converts proteids into peptones which are diffusible; it also acts as an antiseptic. *Artificial* gastric juice is the glycerine extract of the calf's stomach, containing hydrochloric acid.

Gate (*Met.*) Sometimes spelled GEAT or GIT. Also called a SPRUE. (*a*) The channel or ingate by which metal is poured into a mould when casting. (*b*) The metal left in such a channel attached to the casting. There are five kinds of gate, *viz.* (1) POURING GATE; (2) SKIMMING GATE—a recess below the pouring gate for skimming the metal; (3) SPRUE GATES—smaller passages, often two or three in number, leading from the skimming gate to the mould; (4) FEEDING GATES, through which the flow of metal is assisted by agitating with an iron rod; (5) FLOW GATES, up which the metal rises when the mould is full. Nos. 2 to 5 are generally used only in the case of larger castings.

Gatherer (*Glass Manufac.*) The workman who takes the molten glass from the furnace and prepares it for the making of articles.

Gathering (*Binding*). Collecting into volume from printed sheets as they come from the printer. This work is generally done by girls, and may be performed either with the unfolded sheets or with folded sheets which English bookbinders call SECTIONS.

—— (*Build.*) Drawing over the inside of a flue by corbelling.

Gauge (*Build.*) The distance between the battens for slating and tiling.

—— (*Carp. and Joinery*). A tool used for measuring and marking material. *See* MARKING GAUGE, MORTICE GAUGE, *etc.*

—— (*Eng., etc.*) (1) An object used as a standard of measurement. (2) A tool used for making measurements of length (or, less frequently, of area or volume). *See* WIRE GAUGE, *etc.* (3) An instrument for measuring the volume of a fluid (*e.g.* a WATER GAUGE, *q.v.*) or the pressure of a gas (*e.g.* a PRESSURE GAUGE or VACUUM GAUGE, *q.v.*) (4) The distance apart of the rails in a railway or tramway. *See* GAUGE OF RAILWAYS, BROAD GAUGE, NARROW GAUGE, *etc.*

Gauge Cocks (*Eng.*) Small taps or cocks in a boiler, one below and one above the proper water level.

Gauged Arch (*Build.*) *See* ARCH.

Gauged Stuff (*Build.*) Lime putty with a small quantity of plaster of Paris.

Gauged Work (*Build.*) The best kind of brickwork, the bricks being rubbed to shape, set in cement, and jointed with putty (*q.v.*)

Gauge Glass (*Eng.*) A glass tube connected at its ends to the inside of a boiler, so that the upper end is in communication with the steam space, the lower with the water; the level of the water in the tube is the same as the level in the boiler, thus showing at once if the boiler contains the correct amount of water.

Gauge of Railways (*Civil Eng.*) The distance between the inside edges of the rails; this is 4 ft. 8½ in. in England. For light or for temporary railways a narrower gauge is used; thus the Festiniog railway has a gauge of 2 ft. only. The old Broad Gauge, only recently abolished on the Great Western Railway, was 7 ft., and a gauge of 5 ft. or more is used on many lines abroad; in Ireland the standard gauge is 5 ft. 3 in.

Gauge of Tramways (*Civil Eng.*) The standard gauge of 4 ft. 8½ in. is used on most English tramways.

Gault (*Geol.*) A bed of clay of marine origin which, in the south-east of England, lies beneath the Chalk, and forms the lowest member of the Upper Cretaceous Series. The Upper Greensand, or its equivalent, usually comes next above the Gault. It is richly fossiliferous in most localities where it occurs.

Gaultheria (*Botany*). A genus of evergreen aromatic plants (*Ericaceæ*); yields an essential or volatile oil used in pharmacy. Known in the United States as WINTERGREEN.

Gaults. *See* BRICKS.

Gauntlet. A glove, generally made of leather covered with steel plates, worn as a part of mediæval armour. *See* ARMOUR. More recently, a stout glove used in various games and sports. The term is also applied to the part of a glove which widens out and covers the wrist.

Gauss' Theorem (*Elect.*) The TOTAL NORMAL ELECTRIC INDUCTION over a closed surface is 4π times the charge enclosed by the surface.

Gauze (*Textile Manufac.*) A system of weaving in which one set of threads are twisted round the other set, thus producing an open texture fabric. Used for light cloths only. Also styled "cross weaving."

Gay Lussac Degrees. *See* DESCROIZILLES DEGREES.

Gay Lussac's Law (*Chem.*) May be stated thus: when gases combine together they do so in volumes which bear a simple ratio to each other and to that of the gaseous product (all measurements being made at the same temperature and pressure).

Gay Lussac's Measurement of Vapour Pressure (*Phys., Chem.*) *See* VAPOUR PRESSURE.

Gay Lussac Tower (*Chem. Eng.*) A tower suitably packed and attached to the exit of a VITRIOL CHAMBER (*q.v.*) to catch the nitrous gases which escape. Sulphuric acid of 150° Tw. (*see* HYDROMETER) flows down the tower, and dissolves the nitrous compounds as they pass up. *Cf.* GLOVER TOWER.

Ge. Chemical symbol for GERMANIUM.

Gear (*Cycles*). The mechanism by which power is transmitted from the crank axle to the axle of the back wheel. In place of the ordinary chain gear (*see* CYCLES) a bevel gear is sometimes used. Two pairs of bevel wheels are required, connected by a horizontal shaft parallel to or inside one of the horizontal tubes of the back fork. The device is neater than a chain and more easily protected from dust, but more difficult to repair.

Gear (*Eng., etc.*) A term applied in a very wide sense to various arrangements of mechanism, sets of tools, or appliances, etc. In particular, a set of toothed wheels working together.

Gear Cases (*Cycles*). Light cases of leather or celluloid suffice to keep much dust from the chain: these are properly termed GEAR COVERS. A true GEAR CASE is a metal case which not only excludes dust, but is capable of containing a bath of oil at its lowest point; this oil efficiently lubricates the chain and chain wheels.

Gear Cutters (*Eng.*) Milling wheels or circular toothed cutters, used for forming or finishing off the teeth of wheels.

Geared Flywheel (*Eng.*) A flywheel with teeth on its outer edge, for driving some mechanism direct from the engine.

Geared Lathe (*Eng.*) *See* BACK GEAR.

Gear, Height of (*Cycles*). Multiply the diameter of the back wheel by the number of teeth on the large chain wheel, and divide by the number of teeth on the small wheel. The result is the size of the back wheel which would have to be used to carry the rider the same distance in one revolution of the pedals, if the latter were directly fixed to the axle, as in the old high bicycle.

Gearing (*Eng.*) Sets of gear wheels, *i.e.* toothed wheels working together.

Gearing Down (*Eng.*) Reduction of the speed of rotation by means of a set of gear wheels, as in the headstock of a back geared lathe or in the mechanism used to communicate the motion of the motor of a car to the axle of its driving wheels.

Gearing Up (*Eng.*) Increasing [illegible] speed [illegible] rotation of one shaft relatively t[illegible]r by connecting them by a train or set [illegible]eels or some equivalent device.

Geat (*Foundry*). A GATE (*q.v.*)

Gedact Work (*Music*). Those organ stops belonging to the flue work, which consist of closed pipes.

Gedge's Metal. *See* AICH METAL.

Gegenshein (*Astron.*) A bright patch, 10° or 20° in diameter, seen in the sky on the opposite side of the horizon to the rising or setting sun.

Gelatine. A brittle, amorphous, transparent solid; insoluble in cold water, but it absorbs from 5 to 10 per cent. of it, and swells during the process. It is also insoluble in salt solutions, acids, and alkalis. It readily dissolves in hot water, and the solution on cooling forms a jelly. The gelatinising temperature is 30° C. Its chemical constitution is entirely unknown. It contains about 50 per cent. carbon, 6·5 to 7 per cent. nitrogen, 17 to 18 per cent of hydrogen, ·2 to ·7 per cent. of sulphur, and about 25 per cent. of oxygen. Its decomposition products (by putrefaction, treatment with alkalis or acids) resemble those of albumins in many respects, but differ in the large amount of glycocoll (*q.v.*) which is always obtained from gelatine, and in the absence of tyrosine (*q.v.*) Gelatine is obtained from connective tissue, from skins, from the swimming bladder of fishes, and from bones by the prolonged action of boiling water or superheated steam. The gelatine from the swimming bladders is known as ISINGLASS; that from bones, which is not so pure, is called GLUE. Its preparation from bones is as follows: The bones are soaked in weak acid till soft, then washed; digested with superheated steam; the product is run into vessels and allowed to settle; the fat skimmed from the top,

and the gelatine bleached, if required, by sulphurous acid, and filtered; then concentrated by steam pipes. Gelatine is used in preparing jellies, sweets, photographic plates, in numerous copying processes, in clearing soups, etc. Gelatine belongs to the class of substances known as albuminoids; though richer in nitrogen, it cannot replace proteids in a diet.

Gems. *See* PRECIOUS STONES.

Genera (*Biol.*) *See* GENUS.

General Fog (*Photo.*) A partial reduction of the silver salt all over the film during development. There are a number of causes which tend to bring about this, such as exposing the plate to an unsafe darkroom lamp, keeping plates in an unsuitable manner, etc.

General Joiner (*Carp., etc.*) A machine used for a variety of wood working operations—sawing, planing, drilling, etc.

Generating Circle (*Eng.*) The small circle which traces out the cycloidal curve required in setting out the teeth of wheels. A point in the generating circle which rolls on the PITCH CIRCLE (*q.v.*), traces out the curve required.

Generating Surface (*Eng.*) The heating surface of a boiler.

Genouillère (*Armour*). A jointed and flexible piece of armour forming the covering for the knee. *See* ARMOUR.

Genre Painting (*Paint.*) Applied to a style of painting (or to a picture) which depicts scenes of everyday life. The finest examples of genre painting are the pictures by the early Dutch artists. Amongst British artists Hogarth and Wilkie have left notable examples.

Gertian (*Botany*). The bitter tonic medicine is prepared from the dried root of *Gentiana lutea* (order, *Gentianaceæ*), imported from Southern France.

Gentianaceæ (*Botany*). A natural order of *Dicotyledons*, comprising plants of varied habitat. Some of the plants are medicinal.

Genus (*Biol.*) A genus is a group of SPECIES which possess certain structural characteristics in common. A plant or animal is usually denoted by two names: the first or GENERIC NAME being the name of its genus; the second or SPECIFIC NAME being added to denote the species, and thereby to distinguish it from the other species which are included in the same genus. Thus the zoological genus *Felis* includes the Lion (*Felis Leo*), Tiger (*Felis Tigris*), Wild Cat (*Felis Catus*), etc. The botanical genus *Ranunculus* includes the Buttercup, *Ranunculus Acris*; the Great Spearwort, *Ranunculus Lingua*, etc. *See also* SPECIES, ORDER, *etc.*

Geocentric (*Astron.*) A term used when referring measurements to the centre of the earth.

Geodesy. The branch of Applied Mathematics dealing with the measurement of the form and dimensions of large portions of the Earth's surface, or of the Earth as a whole.

Geognosy. A term which was in general use up to the middle of the nineteenth century for the department of Geology which is concerned with rocks (*per se*), and without reference to either their age or their origin. It included two important subdivisions, which were: PETROLOGY (properly so termed), or the study of rock masses as they occur in the field; and LITHOLOGY, or the department of science which is concerned with the mineral constitution of rocks, or the study of specimens by means of the microscope.

Geological Time. A chronological measure (of a somewhat indefinite character) which bears the same kind of relation to the measures of time used in history that the distances of the stellar bodies do to the ordinary standard of terrestrial measurement. Wide differences of opinion exist in regard to the Age of the Earth, as expressed, for example, in centuries. Those who base their conclusions mainly upon certain physical considerations usually set the figure at a much lower estimate than geologists as a whole find themselves able to accept.

Geology. The science dealing with the events that have occurred upon or within the Earth prior to the Dawn of Civilisation. It deals with everything relating to the Succession of Life upon the Earth, to the changes in its physical geography, to the structure and history of its rock masses, to the antecedents of its present surface relief, and to the origin and mode of occurrence of the Earth's economic products. In more general terms it may be said that Geology deals with the History of Former Changes of Life and Land.

Geometrical (*Architect.*) One of the periods into which Sharpe divided Gothic architecture. The name given to the type of tracery used in the geometrical period—the earliest form of bar tracery. This kind of tracery is principally formed of regular figures, such as circles, trefoils, etc., and is much more formal than the later tracery of the Decorated period.

Geometrical Slide. A device which causes a moving part of some apparatus to have certain DEGREES OF FREEDOM (*q.v.*) and no others, so that it shall always move in the same path.

Geometrical Stairs (*Carp., etc.*) Stairs that have a continuous handrail and outside string.

Geometric Clamp (*Phys., etc.*) A device for fixing some part of a piece of apparatus so that it has no DEGREE OF FREEDOM (*q.v.*); that is, its retention in position depends upon the fulfilment of certain kinematical conditions, and not upon any mere application of force: it can be removed and replaced in the identical position it originally occupied.

Geometry. (1) The branch of mathematics which deals with lines, areas, and solids, as distinguished from algebra, which deals with abstract quantities. (2) The branch of the art of drawing which deals with the construction of mathematical figures.

Geraniaceæ (*Botany*). A natural order of *Dicotyledons*, of world-wide distribution. Many of the plants have aromatic and astringent properties.

German Degrees (*Chem.*) *See* DESCROIZILLES DEGREES.

Germanium (*Chem.*) Ge. Atomic weight, 71·8. A very rare metal belonging to the carbon group in the periodic system (*q.v.*); its existence was predicted by Mendélejeff. It was discovered in a very rare silver mineral, ARGYRODITE; also occurs in the rare mineral EUXENITE. It is a lustrous, greyish white, brittle metal obtained by heating the oxide GeO_2 with carbon. Heated in chlorine it forms the tetrachloride $GeCl_4$, a colourless fuming liquid.

German School of Painting. *See* PAINTING, SCHOOLS OF.

German Silver (*Met.*) An alloy of copper (50 to 60 per cent.), nickel (15 to 25 per cent.), and zinc (15 to 20 per cent.) A German silver containing 1 to 2 per cent. of tungsten is called PLATINOID. These alloys have a high electrical resistance—platinoid higher than German silver—which increases uniformly between 0° and 100° C.

Gersdorffite (*Min.*) Nickel sulpharsenide,
$NiS_2 . NiAs_2$;
cubic, in bright tin white crystals, often with a greyish black tarnish. From Sweden, Styria, the Harz, Thuringia, and in good crystals from near Ems.

Geyser (*Geol.*) An intermittent thermal fountain occurring in connection with the quiescent stages of volcanic action. It consists essentially of a tube extending downwards to a zone of high temperature, and connected with some source of water supply. The water in the lower part of the tube becomes gradually heated above the boiling point, until sufficient force accumulates to expel the whole column, which is usually done with explosive violence. The thermal waters commonly leave a deposit of Geyserite around the orifice.

Geyserite (*Min.*) *See* SINTER.

Giallolino (*Paint.*) *See* NAPLES YELLOW.

Gib (*Eng.*) A bar of metal with its ends bent at right angles to its length; used with a cottar or wedge for holding in place the loose strap on the end of certain forms of connecting rod.

Gibbous (*Astron.*) The apparent form of the visible portion of a planet or satellite when more than half but less than the whole illuminated hemisphere is seen.

Gib Headed Key (*Eng.*) A key with one end bent at right angles to its length (similar to a gib),

Giffard's Injector (*Eng.*) A device for forcing a small stream of water into a boiler against the pressure of the water and steam. The necessary energy is supplied by a small jet of steam at a high velocity. The apparatus can be made continuous in action, and has the advantage of possessing no moving parts.

Giggering (*Binding.*) Sliding a line finishing tool (fillet or pallet), in place of working it over the leather. It adds brightness to the gilding.

Gigging (*Woollen Manufac.*) A process of raising on the RAISING GIG (*q.v.*) Applied to certain types of woollen fabrics, rugs, and blankets.

Gilding. *See* ELECTROPLATING, GOLD LEAF, GOLD PAINTS, GLASS MANUFACTURE.

Gimlet (*Carp., etc.*) The ordinary boring tool used for making small holes in wood. The best forms have a helical (or so-called "spiral") fluting running round the shank or stem.

Gimp. A kind of openwork trimming formed of worsted, cotton, or silk twist, with generally a thin wire or cord running through. It is used on dress, furniture, etc.; that used on dress is sometimes covered with beads.

Gin. A form of trap actuated by a spring; used for catching game or vermin.

—— Prepared from the distillation of fermented grain, flavoured with juniper berries and other aromatic substances. The amount of alcohol present is about 45 per cent. The limit to which the spirit can be reduced by the admixture of water under the Food and Drugs Act is 35° under proof.

Gin (*Eng., etc.*) A simple form of hoisting machine; the hoisting rope or chain is wound on a barrel driven by a handle, without any gearing.

——, Cotton (*Cotton Manufac.*) *See* COTTON GIN.

Ginger (*Botany*). The dried rootstocks of the plant *Zingiber officinale* (order, *Zingiberaceæ*) are known to commerce in two forms, the "coated" and the "scraped," according to whether the rind is retained or not.

Gingham (*Cotton Manufac.*) A plain weave of cloth, medium to heavy make, usually of fine warp threads and coarser weft. Generally made in check patterns.

Ginseng (*Botany*). The root of *Aralia Ginseng* (order, *Araliaceæ*) has been long esteemed as a medicine in China. It is also used as an adulterant of senega root.

Girandole (*Furniture, etc.*) (1) Candelabra. (2) Revolving jets of water, as on an ornamental fountain. (3) A pendant or earring.

Girder (*Eng., etc.*) A beam of iron or steel. It may be in one piece, produced by casting or by rolling, or may be built up of a number of plates or bars of wrought iron or mild steel, riveted or bolted together. The latter form is the one now most commonly adopted. The name is also applied to a built up beam of wood and iron, *e.g.* a FLITCH BEAM (*q.v.*)

Girder Bridges (*Eng.*) Bridges carried by girders alone; used where the span is not too great, or where intermediate piers can be erected.

Girth. The circumference of an object.

Girth Measurement (*Dec.*) In estimating the area of painted work or plastering, mouldings are measured round each member by a flexible tape.

Git (*Foundry*). A GATE (*q.v.*)

Give (*Eng., etc.*) A joint or a structure is said to "give" when it yields or breaks under a load.

Gjer's Kiln (*Met.*) A circular kiln of iron plates lined with firebricks and having an inverted cone at the bottom. Used for calcining iron ores for the blast surface; chiefly in the Cleveland district. The same patentee is associated with a pneumatic lift for blast furnaces, and "soaking" pits (*q.v.*) for steel blooms.

Glacé (*Silk Manufac.*) A very closely woven plain silk, thin and bright; tie as tabby.

Glacé Kid (*Leather Manufac.*) Goat skins prepared with high glaze. Originally alum tannage was employed; now chiefly chrome tanned. Properties: very strong, pliable, and light; used for uppers of light boots and shoes. *See* GLAZING.

Glacial Acetic Acid (*Chem.*) A name given to the purest commercially prepared acetic acid; so called because it solidifies to an ice-like mass, which melts at about 16° C. *See* ACETIC ACID.

Glacial Action (*Geol.*) In general terms this may be said to give rise to three sets of results: (1) The transportal of rock débris downhill and seaward from the heart of a mountain area; (2) the mechanical erosion of the sides and the floor of the rocky surface over which the ice is moving; (3) the redeposition of the transported débris in the form of morainic matter, or, in the case of the larger masses of ice, in the form of boulder clay, or more or less

waterworn materials which form ESKERS and other deposits of sand and gravel. *See also* MORAINES.

Glacial Denudation (*Geol.*) *See* DENUDATION.

Glaciation (*Geol.*) *See* GLACIAL ACTION.

Glacier (*Geol.*) Elongated and river-like masses of ice, due to the regelation of half-melted snow and the gradual flow of the resulting semi-solid downhill and seawards along some pre-existent valley shaped by rain and rivers. Glaciers grow only under those geographical conditions in which more snow falls than the summer's heat suffices to melt. Glaciers are important agents in modifying the form of the surface over which they move. Most of the British lakes, for example, are old river valleys which have been locally deepened and widened by the erosive action of glacier ice in former times.

Glaire (*Binding*). White of egg well frothed up, with the addition of a drop or two of vinegar. It is applied to the places which are to be gilded to ensure the adherence of the leaf gold.

Glaive (*Arms*). The name glaive has been applied at different times to different weapons—*e.g.* to the bill, the spear, and the sword. More commonly it refers to the bill (*q.v.*)

Gland (*Biol.*) Certain organs in an animal or plant which secrete fluids having special functions; *e.g.* salivary gland, lachrymal gland, mammary gland, etc.

—— (*Eng.*) The tubular casting which fits into the stuffing box (*q.v.*) of a cylinder, etc., and through which the piston rod slides.

Gland Bolts (*Eng.*) The bolts which hold a gland in place.

Glass Embossing (*Dec.*) Although this work constitutes a trade in itself, it is often carried on in conjunction with sign writing. The process consists of etching a design on the surface of glass by means of hydrofluoric or white (sometimes called French) acid, or a combination of both. The design is usually drawn upon cartridge or manilla paper, and is pounced (*q.v.*) on the face of the glass. A coat of Brunswick black, sometimes mixed with a little beeswax, is then painted over those portions of the surface that are not to be etched. When the black is quite dry, a little wall or embankment made from a mixture of tallow and Burgundy pitch is placed around the edge of the glass to confine the acid. Care being taken that the surface is quite level, the acid is gently poured on, and immediately begins to eat into the glass, the black protecting those parts which it covers. When the etching is sufficiently deep, the acid is poured back into the guttapercha bottle in which it is kept for further use, and the black is removed by softening with turpentine and scraping off. Hydrofluoric acid gives a different surface from French acid, and the two are therefore frequently used one after the other to produce shaded effects. The process is often used on flashed glass such as ruby, the acid removing the coloured surface, and leaving the design or lettering in white upon the ruby ground.

Glassmakers' Soap (*Glass Manufac.*) Manganese dioxide, which, when added to the "metal," removes the green colour due to ferrous silicate.

Glass Manufacture. The discovery of the art of making glass is lost in antiquity. Probably the ancient priests of Egypt were the first to practise its manufacture. At Memphis and Beni-Hassan are to be found, sculptured on the walls of the tombs, unmistakable representations of glass blowers at work. These date from 3900 and 2851 B.C. respectively. The oldest piece of glass known was found at Thebes by Signor Drovetti. It dates from 3064 B.C., is opaque blue in colour, and is now in the British Museum. The early Egyptians used glass to form hieroglyphics for inlaying in stone, wood, or metal, and for personal ornamentation; many examples of these may also be seen in the British Museum. Perhaps the earliest proof of the DOMESTIC USE OF GLASS is found in the frescoes of Thebes, where glass bottles holding wine are represented (1500 B.C.) That the practice of moulding glass was known at that date is apparent by their figures and ornaments, which have every indication of being cast. The colours chiefly employed were opaque dark blue, turquoise, yellow, and white. Both in the British Museum and in the Victoria and Albert Museum can be seen many beautiful specimens of glassware, upon which all these colours are to be found. They consist of small vase-like forms with and without bases and handles; canes or threads of the various colours appear to have been placed around the body in alternate horizontal bands while in the molten state, and at equal distances round the article these circular threads have been pulled together in an upward direction, probably by means of a hook (a method still in use at the present day), producing catenary-like curves, while in others the partial displacement of these undulating bands of different colours is so regular as to suggest the use of a machine. The Phœnicians, Greeks, and early Romans manufactured glass closely resembling that of Egypt, indicating that they obtained their knowledge of glassmaking from the Egyptians, or perhaps employed Egyptian glass workers. The Romans of the later period made glass in great variety of colours and designs, imitating all kinds of gems and stones, and using various opaque colours for decorative purposes. They also practised many methods of casing, or flashing various colours one on another, thus producing what is known as SCULPTURED or CAMEO GLASS. This is made by coating a dark blue opaque glass with a white opaque glass whilst in the molten state, and so uniting them together. It is then blown out into the required shape, and, after being annealed, the portions of the white coatings which form the design are carved, while those not required are removed, thus exposing the dark blue ground. The PORTLAND VASE (British Museum) is a notable example of this style. So remarkable is the knowledge displayed in its manufacture, the elegance of its form, and the expressive modelling of the figures which form the design, that it is regarded as the most magnificent gem of the glassmakers' art extant. The Venetian glass blowers were artists of considerable skill, and introduced many varieties of glassware, elegant in shape and of extraordinary lightness. For a long period Venice excelled all Europe for the beauty of its glass. Venetians revived the art of glass mosaic and window glass painting. They also produced many ingenious designs in ornamental and domestic articles by the use of canes or threads, in white opaque glass, arranged in various patterns, thus producing their LATICINIO, VITRO-DI-TRINA, and PRETICELLI WARE in great variety, examples of which can be seen in the British Museum. AVANTURINE was also invented by the Venetians. This is a soda-lime glass containing copper in a state of reduction, which forms spangles of metallic copper throughout the mass; its manufacture has for a long time been kept a secret, and it is still made at Venice.

The art of glassmaking was carried to the western countries of Europe first by the Romans and later by the Venetians. In the year 1557 Venetian glasses were made at Crutched Friars in London, although at a much earlier period glass of an inferior quality was evidently made in England.

Constituents of Glass.—SILICA, commercially known as sand, is the essential constituent of all glass, and, together with certain metallic oxides, forms by the application of intense heat an amorphous transparent body, every true glass containing at least two metallic oxides. The oxides chiefly used are those of Lead, Potassium, Sodium, Calcium, Barium, Aluminium, and Magnesium. To produce effects of colour the oxides of the following metals are employed, but if used in excess they produce opacity:—*Black:* oxides of manganese and iron. *White:* the oxides of arsenic, tin, and calcium; calcium phosphate, fluorspar, and cryolite. *Yellow:* oxides of cadmium and uranium. *Blue:* cobalt. *Green:* chromium. Different oxides of the same metals are in some cases capable of producing different effects of colour. Iron in the *ferric* state gives a yellow colour, but when present as *ferrous* oxide it gives a bottle-green colour. Manganese dioxide gives a violet colour, whereas the monoxide does not colour glass. Cupric oxide in small quantities gives a *Peacock Blue*, which is converted into *Green* if the quantity of oxide is increased; but from cuprous oxide a rich *Ruby* coloured glass is obtained: this colour is also obtained by using gold. Ruby glass prepared from these metals is colourless when taken from the crucible or pot in which it is made. After being allowed to cool, the ruby colour appears upon reheating. If at this stage the glass be exposed to a high temperature for too long, the ruby colour obtained from gold disappears, and is replaced by a dull brown. By the action of silica at a high temperature it is found that the oxides, carbonates, and sulphates of the metals are decomposed, evolving carbonic anhydride and sulphurous anhydride, and forming silicates of the different metallic oxides, which vary in quality according to the different proportions employed. When two or more substances containing different metallic oxides are fused together with sand, the result will be a mixture of the silicates of the oxides present. *Glass is therefore regarded as a mixture and not a chemical compound.* FLINT or LEAD GLASS is a mixture of the silicates of lead and potassium; BOHEMIAN, of those of potassium and calcium; PLATE and SHEET GLASS, of calcium and sodium; BOTTLE GLASS, of silicates of sodium, aluminium, and calcium; VENETIAN, of sodium, potassium, and calcium. After the ingredients for making glass are thoroughly mixed and put into the pots within the furnace, decomposition of the raw materials takes place, with the expulsion of the gases, and the silica and the metallic oxides combine; the glass passes into the liquid state and remains in this condition so long as the full heat of the furnace is maintained, but if the heat be slightly reduced or the glass exposed to the air, it passes into a state of ductility or viscosity. In the liquid state it can be ladled or poured direct from the crucible for pressed articles and rolled plate. In the viscous condition it can be gathered on the heated end of an iron rod, which, if hollow, enables the mass of glass so collected to be blown into any required shape. By gravitation it can be flattened or elongated, and, by using moulds, made to take any required form. It is also capable of being drawn out into fine threads and tubes.

The manufacture of glass may be divided into two heads: Hollow Ware and Flat Ware. HOLLOW WARE comprises blown glass, bottle glass, blown glass tube, lampwork, and pressed glass. FLAT WARE comprises crown and sheet glass, mosaic glass for windows, plate and optical glass. The BLOWING IRON or hollow iron rod used in the manufacture of hollow ware is from 5 to 6 ft. in length and from ¾ to 2 in. in diameter. The workman gathers upon the heated end of this sufficient glass for making the required article, and by rolling it upon a polished plate of iron (called a MARVER) consolidates and centres the molten mass upon it. The glass is then expanded into a bulb by blowing down the tube: the first stage of manufacture of all glass of this description. By swinging, the bulb is lengthened; and by the aid of a flat square of polished iron with a wooden handle (BATTLEDORE) the end of the bulb can be flattened. Should a stem and foot be required, as in a wine glass, it is either formed out of the end of the bulb which is farthest from the iron, or by the addition of another portion of glass dropped upon the bulb. If the stem is of a fancy shape, it is made separately and attached to the bulb. The foot, if blown, is then made in the form of a circular bulb and attached to the stem, being afterwards heated and opened out. A foot can also be cast on. In this case sufficient glass is allowed to adhere to the end of the stem, and by using two pieces of wood hinged together the workman compresses the soft glass between the open boards and at the same time rapidly rotates the blowing iron upon the arms of his chair, thus causing the glass to assume the proper form. At this stage the body of the article (the bulb) can be covered with fine threads of plain or coloured glass, or decorated with ornamental pinchings. In the primitive stage glass can be blown into any shape by the use of moulds, which are made of wood, carbon, or iron; and its surface can also be impressed with any pattern by the use of dip moulds. If the article requires a handle and foot (*e.g.* a claret jug) the bulb or body is blown to dimensions and correct form and the foot attached as previously explained. The workman then takes the WORKING IRON (a solid rod), on which has been gathered a small portion of molten glass, and fixes it to the centre of the foot; by applying a chilled iron at a point close to the blowing iron, and by giving it a sharp tap, the article is severed from the blowing iron and adheres to the working rod. After reheating what is now the opening or top of the article, the surplus metal is sheared or cut off, and the workman proceeds to form the lip or spout. A portion of molten glass is next gathered to form the handle, which may be either solid or hollow. After being marvered and made to take the form of a circular rod, it is reheated and taken to the maker, who, while holding it in a vertical position, presses down the end of the molten rod of glass upon the body of the jug, so as to form a good connection or sticking; he then pulls away the iron, reduces the thickness of the handle, and cuts it off with the shears to the proper length. The disconnected end is then turned up by means of a small pair of tools, and fastened to the top portion of the article, thus forming the handle. After reheating the jug, so that the whole shall be of an even temperature, it is severed from the working rod and carried to the LEAR, or annealing oven, placed near the source of heat, and gradually removed from it, thus allowing the glass to become annealed. The simplest and oldest arrangement for annealing is a tunnel 30 ft. in length, either heated

at one end by fires on both sides of the lear, or by waste heat from the melting furnace. The goods are placed in pans attached to each other by means of hooks, thus forming a continuous train, which is moved by means of a chain and windlass. The claret jug now passes to the decorator, and if required can be either cut, engraved, etched, enamelled and gilt, or carved. CUTTING: After the design (which usually consists of lines arranged upon a geometrical basis) has been marked or drawn upon the article, it is first "roughed out." This is done by pressing the glass against the edge of an iron wheel revolving in a vertical plane, upon which is allowed to run sand and water from a hopper or container suitably adjusted, the sand cutting its way into the surface; the rough incisions are smoothed by stone wheels supplied with a constant flow of water. These latter range from 3 to 24 in. in diameter, and have cutting edges of different forms, so as to produce a variety of cuts. The pattern is then polished, to regain the transparent brilliancy of the glass, either by wooden (willow wood) wheels or by a rapidly revolving brush, using as a medium pumice powder and rottenstone, and finally putty powder. The last named is a substance obtained by fusing together lead, tin, and antimony. As the oxide forms upon the top of the molten mass it is collected, pounded, and sieved; it is then ready for use, and is found to be the best medium for polishing lead glass; but for polishing lime glass, rouge (oxide of iron) is generally used. ENGRAVING is done by wheels of copper varying from 2 or 3 in. to $\frac{1}{8}$ in. in diameter. These are fastened to the end of a spindle attached to a small lathe, which is generally driven by a foot treadle. The engraving medium used is emery powder and oil; for polishing, rouge or pumice and oil are used, with lead, wood, or cork wheels. The engraver produces a more elaborate design than the cutter, as the work is held underneath the wheel, while in cutting, the article is usually held in a direct line between the workman and his wheel, he having to look through it in order to follow the pattern. This gives the advantage to the engraver, whose work, although not so deeply incised, is capable of greater refinement of form and contour than the cutter's, which is generally stiff and formal. An engraved design can be either left rough from the wheel, partly rough and polished, or, (as in the case of designs which imitate rock crystal) after being more deeply engraved, the design can be polished all over. A style of decoration which has been practised to some extent in recent years is produced by cutting with small stone wheels. It is somewhat similar to the process of engraving, and is very effective. ETCHING consists in the erosion or eating away of the surface of glass by hydrofluoric acid. Patterns are produced by covering the whole surface of the glass with a thin coating of wax, or RESIST, removing those parts intended to be etched, and plunging the article into a solution of the acid. In order to produce a geometrical design, the wax can be removed by the use of a lathe (similar in construction to that employed in turning a rose pattern on wood or metal). The pattern can also be etched down or engraved on copper plate filled in with resist, and transferred to the article; or a lithographer's stone can be used as a means of producing a quantity of transfers of the same design. SAND BLASTING is another method of producing an etched effect upon glass, the parts which are to remain smooth being protected by a stencil of paper or some other clinging material. PAINTING, GILDING, *and* SILVERING are fixed by heat. For painting, white and coloured enamels are used as colours; and an amalgam of gold or platinum, or the powders of the same metals reduced from solutions, are used for gilding and silvering. The enamels are specially prepared so as to fuse at a lower temperature than the article to be decorated; they are applied by means of a brush, and fixed by heating in a muffle furnace. CARVING (CAMEO GLASS): This consists of two or more casings of opaque white and coloured layers of glass one above the other. The design is painted on with resist, and the portions of the surface not required are etched away by hydrofluoric acid. The roughly formed design is then engraved, and finally carved with small tempered steel tools by hand. The ground or background of the design may be polished or left with a matted surface. BOTTLE GLASS: Owing to the presence of ferric oxide in the cheap materials employed in the manufacture of bottles, they are generally of a greenish tint, this being due to the ferric oxide, upon heating, becoming converted into the ferrous oxide; by adding small quantities of manganic oxide and oxide of cobalt to the materials used, an orange or a blue colour is obtained. The furnaces generally in use are of the continuous tank type, the raw materials being put in at one end and the molten glass withdrawn from the other. Bottles are blown in moulds made of brass or iron, which, whilst being used, must be maintained at nearly a red heat. A mould for a cylindrical vessel may be in one piece, but must widen slightly towards the bottom to permit the glass to be removed from it. Bottles having names or markings upon the surface must be blown in moulds which consist of two or three portions. The simplest form of such moulds is in two parts, hinged at the bottom. The gatherer, having collected sufficient glass on the blowing iron, passes it over to the blower, who, having slightly expanded the bulb by blowing down the iron, marvers it until it assumes a conical form. He then inserts the bulb of molten glass into the mould, which he closes with his foot; by blowing down the iron he forces the bulb to take, both *externally* and *internally*, the internal form of the mould. He opens the mould, and removes the bottle attached to the blowing iron. After having "wetted it off" by applying a moistened tool to the neck, it is handed to the workman who fashions the lip by coiling a small piece of molten glass round the neck, and by the aid of a special tool, which he inserts in the neck of the bottle, forms and finishes the lip. The bottle is then taken to the annealing kiln, which, when completely filled, is allowed to cool. PRESSED GLASS: The cheaper articles for domestic use are not made by hand, but by the use of lever and screw presses and stoutly made moulds. The molten glass takes the form of the mould upon its outer surface, while the inner surface is formed by a metallic plunger. The base, body or collar, and top of the mould, in which the plunger fits, are all accurately fitted and hinged together. The mould is firmly fixed upon the table of the press immediately underneath the plunger, which is attached to the end of a screw. By the aid of a fixed crossbar working in vertical slides, movement is obtained by revolving a flywheel, which is rigidly connected to the screw. This causes the plunger to descend with considerable force, and at once presses the molten glass into the shape of the mould. Pressed glass always requires to be polished by reheating the outer surface, to take away the roughness caused by the chilling action of the mould. CROWN *and* SHEET GLASS: The oldest

method of manufacturing glass for glazing purposes in this country is that known as crown glass making. The workman having gathered sufficient glass from the pot, marvers it, or gives it a conical form by turning it in a block of wood or metal, hollowed out to the required shape—the apex of the cone forming the BULLION POINT. The glass is now slightly expanded, reheated, and blown until it assumes the shape of a huge decanter having a flat bottom and a very short neck. A PONTY, or working rod, is attached to the bullion point, and the form severed from the blowing iron. The workman standing in front of the furnace, with a veil before his face, reheats the form; by rapidly revolving the iron the glass expands into a thin transparent circular plate. This plate, now called a TABLE, usually about 54 in. in diameter, is detached by shears from the ponty and lifted into the annealing kiln upon a fork. The cutting up of the circular table of glass in rectangular sheets causes much waste, and the bull's eye in the centre confines the sheets to rather small sizes as compared with those made by the cylindrical method. SHEET GLASS, in its preliminary stage, is made similarly to crown glass, being formed in hollow blocks of wood or metal; but it is expanded by the blower to the diameter ultimately required. The block, if of wood, is sprinkled with water to prevent it from burning, and to prevent scratching of the glass. A hollow iron block, through which water is allowed to pass to keep it cool, is sometimes used, the surface of the block being covered with charcoal to prevent scratches. The blower, after having reheated the bulb of molten glass, stands over a pit, or well, some 10 ft. deep, and swings the bulb round in a vertical plane, and also backwards and forwards, until the mass expands into a huge cylinder of the required length, the diameter being determined by the block, and remaining the same throughout. The cylinder is opened at the end remote from the iron. Thin ones are opened by forcing in air through the pipe and stopping up the aperture. Upon reheating the end, the expansion of the air within the cylinder causes it to burst open. The opening is then widened out to the size of the cylinder by swinging to and fro, with the opening downwards. The thicker kinds are opened by attaching a lump of hot glass to the end; air is forced in and the cylinder burst open, the opening being enlarged by cutting with scissors. The cylinder is then placed upon a wooden rest and detached from the blowing iron by wrapping round it a thread of hot glass. This is quickly removed, and upon a cold iron being placed against the part previously covered by the hot thread, the end which was attached to the blowing iron breaks away. The cylinder is then split longitudinally along the inside by a diamond attached to a long handle guided by a wooden rule. It is now taken to the flattener, who, after warming it in his furnace, places it with the split uppermost upon the flattening stone, upon which is placed a sheet of glass called a LAGRE. The heat of the furnace causes the cylinder to open out, and the flattener rubs down the wavy sheet into a flat surface with a POLISSOIR (a rod of iron with a block of wood at one end). The sheet is afterwards removed to a cool part of the furnace and allowed to anneal. PATENT PLATE is sheet glass specially selected, and ground and polished by machinery. The average sizes of sheets are 48 × 34 to 36 in., but by the assistance of a mechanical arrangement (called the IRON MAN) sheets are made up to 82 × 42 in. PLATE GLASS is manufactured by pouring the molten glass from the pot (taken from the furnace) upon a smooth, flat iron table some 30 to 40 ft. long by 15 to 20 ft. broad, and by passing a smooth parallel iron roller of cast iron, some 2 ft. in diameter and weighing many tons, backwards and forwards over the surface of the molten mass, by men hauling upon tackle attached to the ends. The glass is rolled into rough plate, the thickness of which is determined by strips of iron placed upon the table, and upon which the ends of the roller bear, the distance apart of these strips determining the width of the plate. The plate being "cast," it is thrust from the table into the annealing oven, which is closed up and allowed to cool. The rough plates are used for lighting purposes; if required for mirrors, etc., they are ground and polished. To effect this the plate is first bedded in plaster of Paris upon a revolving table, and cast iron rubbing plates are laid upon it, each having a central pivot or pin which works in the eyes of two fixed radial rods carried to cast iron standards erected outside the revolving table. Sand and water are allowed to flow upon the plate, and the surface is ground flat. The grinding process is completed by the use of powdered emery. The plate is turned over and the process repeated. The plate is next smoothed by bedding it upon another table or machine, but instead of iron plates, sheets of glass are used for rubbing, with finely powdered emery and water as a medium, beginning with the coarsest grain and finally finishing off by hand, using wood blocks with flour emery and water. Polishing is performed on another machine, the table having an alternating sideway motion at a slow speed under a pair of arms moving at a high speed and at right angles to that of the table. Upon the arms, at intervals of 12 in., weighted spindles are placed, at the bottom of which are discs of wood capped with felt; these are put upon the surface of the plate which is bedded upon the table. Rouge and water are squirted upon the glass with syringes, and the surface polished. Both sides of the plate are treated in this way. These plates vary in thickness from $\frac{3}{8}$ to $\frac{5}{8}$ in., and are cut up into required sizes with a diamond. Plate glass used for mirrors and windows can be decorated by etching, engraving, and light cut patterns. G. J. C.

Glass, Natural (*Geol.*) Volcanic products, due to the rapid cooling of a fluid mass of rock from its initial high temperature. OBSIDIAN is a natural glass, having about the same composition as that of granite. Many pitchstones bear the same relation to syenite, while the native glass known as TACHYLITE is the glassy representative of the gabbros, dolerites, and basalts.

Glass Paper *or* **Cloth.** Sheets of tough paper or a thin fabric, the surface of which is covered with finely crushed glass (caused to adhere by glue). Used for smoothing surfaces of wood, etc. *See also* SANDPAPER.

Glass Papering Machines (*Joinery, etc.*) Machines which give rapid rotation to a disc or roller covered with glasspaper; this can be brought in contact with the surface of woodwork requiring to be glass papered.

Glass, Soluble. *See* SOLUBLE GLASS.

Glassy Felspar (*Min.*) A variety of ORTHOCLASE (*q.v.*) occurring in vitreous crystals in volcanic rocks.

Glauberite (*Min.*) Calcium sodium sulphate, $CaNa_2(SO_4)_2$; monosymmetric. Occurs in association with gypsum, rock salt, borax, etc.

Glauber Salt (*Min.*) A synonym for MIRABILITE (*q.v.*)

Glauber's Salt (*Chem.*), $Na_2SO_4 10H_2O$. Sodium sulphate crystallised below 34° C., when it crystallises with ten molecules of water of crystallisation. *See* SODIUM COMPOUNDS.

Glauconite (*Min.*) A hydrous silicate of iron and potassium of somewhat variable composition. It occurs in small grains of a greyish or olive green colour in the Greensand and some other rocks. It is not known crystallised.

Glaze (*Pot.*) Glaze is that which forms the gloss or smooth transparent surface on pottery or porcelain. It may be either colourless or coloured. Generally composed of an admixture of alkalis with silica, lime, and often oxide or carbonate of lead. A glaze is said to be "hard" if it requires a great heat to melt it, and "soft" if it is melted at a low temperature. *See* HARD PASTE.

Glazed (*Build.*) Filled in with glass.

Glazed Boards. Millboards that have been subjected to great pressure. Printed sheets are sometimes placed between glazed boards in a press to impart a more finished appearance.

Glazed Brick (*Build*). A brick used for facing, having a glazed surface.

Glazed Frost (*Meteorol.*) When damp air at the beginning of a thaw comes into contact with very cold ground, a thin sheet of ice is sometimes formed. Rain or a warm wind coming suddenly after a frost will sometimes produce this effect.

Glazing (*Eng., etc.*) The clogging of the surface of a grindstone by the material removed from the metal which is being ground.

—— (*Leather Manufac.*) A process by which a high gloss is given to leather. The skin to be glazed is coated over with a solution of albumen, and glazed when dry by a glazing machine. Calf boot leather is glazed by brushing with a solution of wax and soap, and polishing with brush or cloth.

—— (*Plumb.*) Going over a wiped joint with a hot iron, in order to produce a finished surface.

Glazing Colour (*Dec.*) A transparent colour used over a comparatively dull ground to increase its brilliancy: thus, when a very bright green is required, a light green is glazed over with emerald green (*q.v.*), which has very little body (*q.v.*) The madder lakes are often used to enrich the effect of red grounds.

Globigerina Ooze *or* **Foraminiferal Ooze** (*Geol.*) An accumulation of the calcareous shells of various kinds of foraminifera which gathers on the ocean floor at considerable depths, and which prevails there over a large area of the Earth's surface. In past times deposits of essentially the same nature have given rise to considerable groups of strata, some of which form important geographical features.

Globular Lightning (*Meteorol.*) An electrical phenomenon whose nature is not understood: an appearance resembling a globe of fire, sometimes visible for a number of seconds, is produced.

Globular Structure (*Geol.*) A general term which is applied indifferently to such cases as those where concretions have grown into ball-like masses; to the spheroidal structures developed in some vitreous rocks; and to the bomblike forms assumed by some basalt or andesite lavas in cases where they have flowed into water.

Globulins (*Chem.*) A class of proteid substances very similar to the albumins, but differing from them in being insoluble (or very difficultly soluble) in water, soluble in dilute salt solutions from which they are precipitated on further dilution or removal of the salt by dialysis, insoluble in saturated solutions of sodium chloride and magnesium sulphate, insoluble in half saturated ammonium sulphate solutions. They are precipitated from their solutions by dilute acids. After being precipitated by acids or by removal of salt by dialysis, they quickly become insoluble. Some of them are acids, having an acid reaction to litmus. Examples of globulins are serum globulin, cell globulin, crystallin (in the crystalline lens of the eye).

Glockenspiel (*Music*). *See* MUSICAL INSTRUMENTS—PERCUSSION (DEFINITE SOUND).

Glory (*Art*). *See* AUREOLA.

—— (*Meteorol.*) *See* FOG IMAGE.

Glory Hole (*Glass Manufac.*) *See* FURNACES (GLASS).

Gloss (*Dec.*) Fine oil paint is an important indication of the proper mixing and good quality of the ingredients. If good linseed oil is used, the paint will always show a good gloss. A little varnish is often added to paint to increase the gloss; but if too much is used the paint is likely to "curdle." Some painted work is finished entirely without gloss. *See* FLATTING MATT.

Glost Oven (*Pot.*) After the bisque ware has been dipped in the glaze it is fired in the GLOST OVEN to melt the glaze. *See* BISQUE *and* ENAMEL KILN.

Glove Leather (*Leather Manufac.*) Made from lamb and kid skins. The leather is prepared by a tannage or tawing process, the ingredients consisting of alum, salt, flour, and egg yolk, mixed to a paste with water. The paste is got into the skins either by TREADING (France and Germany) or by DRUMMING in large revolving drum (England). *See* DRUMMING.

Glover Tower (*Chem. Eng.*) A reaction tower placed between the pyrites-burners and vitriol chamber in the manufacture of sulphuric acid. The hot sulphur dioxide from the burners passes up the tower and decomposes the nitrosulphuric acid from the GAY LUSSAC TOWER (*q.v.*), carrying the nitro compounds forward into the chambers.

Glow (*Met.*) Sky glow accompanies the rising and setting of the sun, and is due to the diffraction and reflection of light by the minute particles in the air. Magnificent coloured glows usually accompany large volcanic outbursts.

—— **Counter** (*Astron.*) *See* GEGENSHEIN.

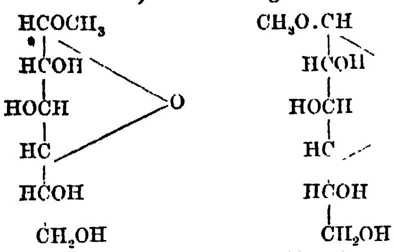
Glucinum (*Chem.*) BERYLLIUM (*q.v.*)

Gluconic Acid (*Chem.*), $CH_2OH.(CHOH)_4.COOH$. A syrupy liquid which readily passes into its lactone (*see* LACTONES); a crystalline solid. It is dextrorotatory; its lævo and inactive forms are known. It is obtained by heating dextromannonic acid with quinoline; also by oxidation of dextrose with bromine water. On reduction it yields dextrose. It is very important in the synthesis of dextrose (*q.v.*) and lævulose.

Glucosazone (*Chem.*) *See* OSAZONES.

Glucose (*Chem.*) Another name for DEXTROSE (*q.v.*)

Glucosides (*Chem.*) Are ether derivatives of glucose. Many glucosides which occur naturally are very important substances; they are resolved by enzymes (*q.v.*) and by dilute acids and alkalis into glucose, and the other substances united with it in the glucosides. For examples of glucosides *see* AMYGDALIN, SALICIN. The simplest glucoside is methyl glucoside, which is prepared by the action of hydrochloric acid on glucose dissolved in methyl alcohol. It exists in two stereoisomeric (*see* STEREOISOMERISM) forms having the formulæ:



α-Methyl Glucoside. *β*-Methyl Glucoside.

The enzyme invertase hydrolyses the *α* form, but not the *β* form; while emulsin hydrolyses the *β* form, but not the *α* form. The natural glucosides are hydrolysed by emulsin just as *β*-methyl glucoside is. As invertase can only split 1 molecule of glucose from the amygdalin molecule, while emulsin can split off 2 molecules, it is concluded that amygdalin (*q.v.*) contains the two glucose molecules in the form of maltose (*q.v.*)

Glucosone (*Chem.*) *See* OSAZONES.

Glue. An impure form of gelatine made from bones, skin, and animal refuse generally. The colour and quality vary considerably, according to the material from which the glue is manufactured. Good glue is wholly insoluble in cold water, but absorbs a quantity when immersed, sometimes as much as four times its weight. There are many processes of glue making, but they all consist of digesting the bones or hides, clarifying the gelatinous liquor, and running into moulds. The jelly is then cut up into slices, which are placed on nets in a stove to dry. *See* SIZE.

Glue Pot. Glue is usually melted in a vessel surrounded by an outer vessel which forms a water bath. This subjects the contents to a steady temperature not exceeding 212° F.; and the hot water in the outer vessel serves to retain the heat when the pot is removed from the stove for use.

Gluing (*Carp., etc.*) Gluing consists essentially in filling the interstices between two surfaces of wood (or other material) with a *thin* layer of glue. All superfluous glue should be expelled by squeezing (or by rubbing the surfaces together when possible).

Glume (*Botany*). The two scales at the base of the spikelet in the inflorescence of a grass.

Glutaminic Acid (*Chem.*), *α*-Aminoglutaric acid, $COOH.CH_2CH_2CHNH_2COOH$., is a decomposition product of albumin on boiling with hydrochloric acid: it is also widespread in the vegetable kingdom. Forms shining octahedra; soluble in hot water. It is dextrorotatory.

Glutaric Acid (*Chem.*), $COOH.CH_2.CH_2.CH_2.COOH$. Forms shining prisms very soluble in water; melts at 97°. It forms a characteristic zinc salt. It occurs in wool fat and in turnip juice. It may be obtained from sodium malonic ester (*see* MALONIC ACID) by action of methylene iodide:

$$2\,CHNa(COOC_2H_5)_2 + CH_2I_2 = CH_2\begin{cases}CH(COOC_2H_5)_2\\ CH(COOC_2H_5)_2\end{cases} + 2NaI$$

On saponifying this ester and heating the product, it yields glutaric acid. The acid is also produced by treating dihydroresorcin with sodium hypobromite—an example of change from a benzene ring compound to a fatty compound. On slow distillation it yields an anhydride which yields an IMIDE, $CH_2\begin{cases}CH_2.CO\\ CH_2.CO\end{cases}NH$, with ammonia: this amide is produced by oxidation of PIPERIDINE with hydrogen peroxide. DIMETHYLGLUTARIC ACID, $COOH.CH_2CH_2.C(CH_3)_2.COOH$, is an oxidation product of camphor.

Gluten (*Chem.*) The substance obtained when flour is made into dough and the latter washed free from starch by water. It is not present in flour, but is generated from the flour proteids by the above treatment. When moist, it is a yellowish grey sticky mass; on account of its tenacity it retains the carbonic acid in dough when yeast is added or carbon dioxide is passed into it, thus making bread light. Gluten is not a single substance; next to nothing is known of its chemistry. *See* BREAD.

Glutin (*Chem.*) Another name for GELATINE (*q.v.*)

Glyceric Acid (*Chem.*), $CH_2OH.CHOH.COOH$. A syrupy liquid soluble in water and alcohol. It contains an asymmetric carbon atom (*q.v.*) (the middle one); and the inactive acid can be resolved into its two components—*Penicillium glaucum* destroying the ammonium salt of the dextrorotatory variety and leaving the lævorotatory salt, while the *Bacillus ethaceticus* destroys the lævorotatory acid only. The inactive acid is obtained from glycerine by oxidation with dilute nitric acid.

Glycerine (*Chem.*), $CH_2OH.CHOH.CH_2OH$. A colourless, odourless, viscous liquid with sweet taste. Boils at 290° C.; it is about a quarter as heavy again as water; burns with pale blue flame; is very hygroscopic, readily absorbing moisture from the air. It mixes with water and alcohol in every proportion, but it is insoluble in ether, benzene, chloroform, carbon disulphide. It is a very powerful solvent, dissolving many salts just as water does; it also dissolves many metallic oxides, *e.g.* lead oxide. It is a constant product of the alcoholic fermentation of sugar. In nature it occurs combined with the "fatty acids" in fats (*q.v.*) It is prepared on an enormous scale as a by-product in the preparation of fatty acids for candle making, and in the manufacture of soaps. In the first case the fat is resolved into fatty acid and glycerine by treatment with superheated steam in presence of a little lime; in the second case by boiling with caustic soda or potash, and the glycerine is purified by processes too complex to be given here. The following are important reactions of glycerine: (1) Heated with sulphuric acid or potassium hydrogen sulphate it gives acrolein (*q.v.*); (2) with amorphous phosphorus and iodine it gives allyl iodide, isopropyl iodide, and propylene; (3) oxidised by dilute nitric acid it gives glyceric acid (*q.v.*); (4) with bromine water it gives GLYCEROSE, a mixture of the aldehyde $CH_2OHCHOHCHO$ and

Ketone $CH_2OHCOCH_2OH$ (*see* SUGARS); (5) with alkaline permanganate it gives oxalic acid; (6) with mixture of nitric and sulphuric acids it gives NITRO-GLYCERINE (*q.v.*); (7) it dissolves boric acid on heating, forming the preservative BOROGLYCERIDE. It is used in medicine and as a lubricant for watches. *See* QUINOLINE. When the hydroxyl groups in glycerine are replaced by chlorine, compounds called CHLORHYDRINS are produced; when a terminal OH group is replaced, α-MONOCHLORHYDRIN results; when the middle OH group is replaced, β-MONO-CHLORHYDRIN results; when two terminal OH groups are replaced, α-DICHLORHYDRIN results; when two adjacent groups are replaced, β-DICHLOR-HYDRIN results. They are all liquids, and are produced in the order given above by the action of hydrochloric acid on glycerine, by the action of hypochlorous acid on allyl alcohol, by the action of hydrochloric acid on glycerine, and by the action of chlorine on allyl alcohol.

Glycerol (*Chem.*) Another name for GLYCERINE (*q.v.*)

Glycin (*Photo.*) Para oxyphenylglycin, $C_6H_4OHNHCH_2COOH$. A developer somewhat resembling ferrous oxalate in being slow in its action. It develops images perfectly free from fog, even without the use of bromide. It is extremely valuable in developing a number of plates together by what is known as stand development (*q.v.*)

Glycine (*Chem.*) Another name for GLYCOCOLL (*q.v.*)

Glycocholic Acid (*Chem.*), $C_{26}H_{43}NO_6$. A colourless crystalline solid; melts at 132° to 134°; very sparingly soluble in water (less than 1 in 1,000); dextrorotatory. It occurs in the form of its sodium salt in the bile of all animals. Boiled with acids or alkalis, it yields glycocoll (*q.v.*) and cholalic acid—a substance of unknown constitution. Glycocholic acid is monobasic, and its alkali salts are easily soluble in water and in alcohol.

Glycocoll (*Chem.*), CH_2NH_2COOH (*amido- or aminoacetic acid*). A crystalline solid with sweet taste; melts with decomposition at 232° C.; soluble in water, insoluble in alcohol. It is a decomposition product of albumin, and especially of gelatine (*q.v.*) It occurs combined with salicylic acid in urine as salicyluric acid when salicylic acid has been taken; and combined with benzoic acid as hippuric acid (*q.v.*) normally in the urine of herbivora; it also occurs combined with cholic acid as glycocholic acid in bile. It is best prepared by boiling hippuric acid with hydrochloric acid; it may also be obtained synthetically by acting upon monochloracetic acid with ammonia; also by the action of hydriodic acid upon cyanogen. As it contains a basic group (NH_2) and an acid group (COOH), it forms two series of salts. Heated with baryta it yields methylamine. With ferric chloride it gives a red colour. Sarcosine and betaine are its mono- and trimethyl derivatives respectively (*see* these). *See also* DIAZO COMPOUNDS.

Glycogen (*Chem.*), $(C_6H_{10}O_5)n$. Animal starch. A white powder which forms an opalescent solution in water. It occurs in the liver of animals. It is dextrorotatory; gives a red colour with iodine. Acids convert it into glucose, and ferments convert it into maltose.

Glycollic Acid (*Chem.*), $\begin{array}{l}CH_2OH\\|\\COOH\end{array}$. A white crystalline solid; melts at 80°; very soluble in water. It occurs in the juice of unripe grapes and in turnip juice. It is prepared by boiling monochloracetic acid with water; it is also produced by oxidation of alcohol or of glycol by nitric acid, and by the action of nitrous acid upon glycocoll; it is also formed when oxalic acid is reduced by sodium amalgam. On heating it forms anhydrides. Nitric acid oxidises it to oxalic acid. It behaves like an alcohol and an acid.

Glycols (*Chem.*) Are dihydric alcohols of the paraffins. When the (OH) groups are adjacent we have the α-glycols, when separated by one carbon atom the β-glycols, and so on; *e.g.*

$\begin{array}{l}CH_2OH\\|\\CH_2OH\end{array}$	$\begin{array}{l}CH_3\\|\\CHOH\\|\\CH_2OH\end{array}$	$\begin{array}{l}CH_2OH\\|\\CH_2\\|\\CH_2OH\end{array}$
Ethylene Glycol (the simplest possible glycol).	α-Propylene Glycol.	β-Propylene Glycol (Trimethylene Glycol).

Ethylene glycol, commonly called GLYCOL, may be regarded as a type of these compounds. It is a thick sweet liquid; boils at 197°. It is obtained by boiling ethylene dibromide with potassium carbonate and water. With hydrochloric acid at 160° it forms ethylene chlorhydrin, $\begin{array}{l}CH_2Cl\\|\\CH_2OH\end{array}$; with concentrated sulphuric acid it forms the sulphate; with a mixture of sulphuric and nitric acids it forms the dinitrate. Nitric acid oxidises it to

$\begin{array}{l}CH_2OH\\|\\COOH\end{array}$	$\begin{array}{l}CHO\\|\\CHO\end{array}$	$\begin{array}{l}CHO\\|\\COOH\end{array}$	$\begin{array}{l}COOH\\|\\COOH\end{array}$
Glycollic Acid.	Glyoxal.	Glyoxylic Acid.	Oxalic Acid.

Phosphorus pentachloride gives ethylene chlorhydrin. Sodium gives first monosodium glycol, $\begin{array}{l}CH_2OH\\|\\CH_2ONa\end{array}$; then disodium glycol, $\begin{array}{l}CH_2ONa\\|\\CH_2ONa\end{array}$

Glyoxal (*Chem.*), $\begin{array}{l}CHO\\|\\CHO\end{array}$ A colourless amorphous solid which contains water: very soluble in water, alcohol, ether. It is obtained by the action of nitric acid on glycol, glycollic acid, alcohol, or aldehyde: it is best prepared from the last of these. It gives the usual reactions of an aldehyde with sodium hydrogen sulphite, with hydrocyanic acid (*see* TARTARIC ACIDS), with hydroxylamine, and with phenylhydrazine; also with ammoniacal silver. But with ammonia it yields as principal product a heterocyclic ring compound called GLYOXALINE,

$$\begin{array}{l}\quad\ \ (N)\\(\beta)CH\,.\,NH\diagdown\\ \quad\ |\qquad\qquad\ \ \rangle CH\ (\mu)\\(\alpha)CH\ .\ N\diagup\end{array}$$

(the letters are used in naming substituted glyoxalines), a white solid melting at 90° and acting as a strong base; it has many derivatives. When glyoxal is treated with an alkali, one half of the molecule is oxidised and the other half reduced, and glycollic acid results:

$$\begin{array}{l}CHO\\|\\CHO\end{array} + H_2O = \begin{array}{l}CH_2OH\\|\\COOH\end{array}$$

Glyphs (*Architect.*) Vertical channels used in the Doric frieze. *See* TRIGLYPH *and* DIGLYPH.

Glyptics (*Art*). The art of engraving or carving, especially engraving on precious stones. This art was extensively practised by the Egyptians and the Greeks.

Glyptograph (*Art*). An engraving on a precious stone.

Glyptotheca. A gallery in which works of sculpture are placed.

Gnat (*Zool.*) An insect belonging to the order *Diptera* (two-winged flies), which also includes the housefly, gadfly, and midge.

Gneiss (*Geol.*) Strictly speaking, this term is applied only to any banded aggregate consisting essentially of crystalline felspar, together with folia, leaflike bands of one or more of other rock forming minerals. In a few cases gneiss has evidently arisen through the deformation and subsequent reconstruction of an eruptive rock. In most other cases it appears to be due to the action of alkaline water at high temperature and pressure operating upon old sediments. Its minerals in some cases resemble those of granite; but there are syenite gneisses, diorite gneisses, gabbro gneisses, and other kinds.

Gnomon (*Astron.*) (1) A vertical rod used by the Greeks to observe the motion of the sun by watching the shadow. (2) The rod or plate whose shadow indicates the time on a SUN DIAL (*q.v.*)

Gobelins. The State factory of tapestry, established in Paris. The factory was founded by the family of this name in the fifteenth century, and became a royal establishment under Louis XIV. It has always been famous for the excellence of the work and the beauty of the colours employed.

Gobony (*Her.*) *See* COMPONY.

Godroon, Gadroon (*Art*). A system of ornament formed of convex curves or arcs joined at their extremities: used chiefly in the ornamentation of plate and vases, but also in architecture, costume, etc.

Going (*Joinery*). The horizontal distance between two risers (*q.v.*) in a staircase.

Going Barrel (*Watches, Clocks*). A barrel with the main wheel teeth cut upon it, driving the train direct, no fusee being used. The energy reaching the escapement is variable, being greatest when the spring is fully wound; but this has little effect on the rate of a timepiece governed by a balance and spring, and simplifies the mechanism, especially in a keyless watch. *See* TRAIN, FUSEE.

Going Part (*Textile Manufac.*) *See* BATTEN.

Gold (*Chem.*), Au. Atomic weight, 197. A yellow metal; specific gravity, 19·3; melts at 1,037° C. When pure it is absolutely unchanged in air. It is dissolved by concentrated selenic acid, forming auric selenite; also by aqua regia and by solutions of chlorine (the aqua regia acts upon it by virtue of the chlorine liberated by it), forming auric chloride, $AuCl_3$; also by dilute potassium cyanide solution in presence of air. The pure metal is extremely malleable: the thickness of gold leaf is about $\frac{1}{280000}$ of an inch. When viewed by transmitted light, gold leaf is seen to be green. When the gold leaf is made still thinner by treatment with dilute potassium cyanide solution, which dissolves gold, it transmits successively blue, violet, and red light. GOLD LEAF is made by rolling gold, then beating it out in calfskin, and finally in goldbeaters' skin (a membrane prepared from the outer sheath of the intestines of the ox). Gold is also very ductile: the gold in four sovereigns can be drawn into a wire equal in length to the earth's circumference. Gold always occurs free, but not pure; it is usually alloyed with copper, silver, tellurium, etc. Many methods are in use for extracting gold from the earthy and metallic impurities associated with it in nature: (1) Alluvial deposits are washed by a powerful stream of water into a sloping channel, the bottom of which contains crevices into which mercury is poured. The gold, being far heavier than the earthy matter washed into the channel with it, rapidly sinks and amalgamates with the mercury. (2) When the gold occurs in rock, this is broken up, then ground to powder with water. In the stamps, or grinding machine, amalgamated copper plates are placed to take up some of the gold, while the rest of the pulp is run over sloping amalgamated copper sheets, which take up more gold. The stream of powdered ore and water is run into settling tanks, when the gold which has escaped amalgamation settles, and is recovered by one of the following chemical processes: The gold amalgam from process (1), or the amalgam scraped from the copper in process (2), is distilled to free it from mercury. (3) If the gold is finely divided the material may be placed in closed vessels, and, after moistening, acted on by chlorine gas, which forms the very soluble chloride of gold. If the ore contain pyrites it must first be roasted to drive off sulphur; also the chlorine must not contain hydrochloric acid. The gold chloride is washed out of the ore by water, and the gold precipitated by ferrous sulphate solution. The black powder is melted and cast into ingots. (4) Finely divided gold is dissolved by a dilute solution of potassium cyanide in presence of air, forming a soluble double cyanide of gold and potassium, $2Au + 4KCN + H_2O + O = 2K . Au(CN)_2 + 2KOH$. The solution obtained by this process is deprived of its gold either by precipitation with zinc or by electrolysis. In the former case the gold is rubbed off from the zinc and melted and cast into ingots. A modification of process (3) consists in using chlorine gas and bromine vapour under pressure; and a modification of process (4) in using cyanogen bromide as well as potassium cyanide. When it is desired to extract a small quantity of gold from gold-containing silver (*e.g.* in assaying), the process known as PARTING BY SULPHURIC ACID is employed. The metal is granulated (*i.e.* melted and poured into cold water), and then boiled in leaden vessels with strong sulphuric acid, which converts the silver into silver sulphate and leaves the gold unchanged. During the process the sulphur dioxide which escapes is reconverted into sulphuric acid. The silver sulphate is dissolved in boiling water, the solution removed, leaving the gold behind as a black powder, which is collected when a sufficient quantity has been obtained, and melted. The silver is recovered by precipitation with copper. When gold is required quite pure, it is melted, and a current of chlorine gas is led into it, when copper, silver, arsenic, etc., are converted into chlorides, all of which volatilise except the silver chloride, and this forms a scum on the top of the melted gold, and is easily removed when the whole has solidified. The TOUCHSTONE is commonly employed in testing the purity of gold; it is a piece of black basalt or slate, on which the article to be tested is rubbed, and the streak is treated with fairly strong nitric acid containing a little hydrochloric acid. The effect produced on the streak is compared with the effect produced on streaks made by TOUCH NEEDLES containing a known proportion of gold. In this way

the proportion of gold can be estimated with fair accuracy; but if the article be coated with pure gold, a part of the surface must be ground off on the touchstone. The proportion of gold in an alloy is expressed in carats. Pure gold is 24 carat gold; the gold coinage is 22 carat (*i.e.* it contains twenty-two parts gold and two parts of copper in twenty-four parts). This coinage alloy is much harder than pure gold; it has a specific gravity of 17·2, and melts at 946°. Aluminium forms remarkable alloys with gold. An alloy containing 10 per cent. of aluminium is white, and melts about 620°; an alloy containing 22 per cent. of aluminium has a fine purple colour, and melts above the melting point of gold.

Gold (*Min.*) This element occurs native in crystals of the cubic system (usually in complex aggregations), but more often in a granular condition, in alluvial deposits, and disseminated in quartzose metamorphic rocks, where it is *in situ*. It is frequently associated with precious stones, as zircin, ruby, garnet, topaz, etc., and with certain metallic minerals, as tellurium ores, and platinum, and magnetic and titanic iron. Silver to the extent of nearly 30 per cent. may be alloyed with it, as may also copper, iron, palladium and rhodium, the latter to the extent of 40 per cent. in rhodium gold. It is of a characteristic colour, but its chief distinguishing feature is its ductility and malleability. It has been found sparingly at several places in the British Isles; it is also obtained from many places in Europe, as Konisberg, Schemnitz, Kapnite, Offenbanya, Piedmont, etc.; from the Urals, China, Thibet, India, the West Coast of Africa; largely in South Africa, Australia, India, California, Klondike, New Zealand, and Tasmania.

Gold Amalgam (*Min.*) A native amalgam of gold, silver, and mercury containing about 40 per cent. of gold. It has a whitish colour, and occurs in grains or in small crystals. It has been found in California, Central America, Australia, and Siberia.

Gold and Black Marble (*Dec.*) This marble is imitated in various ways, the simplest being to paint a solid ground in bone or ivory black, and to put in the golden yellow veins with a mixture of white, ochre, and Indian red, or raw and burnt sienna. The black spaces between the veins are then glazed with a transparent grey tint, and finally very thin white veins are put in. The marble is not difficult to imitate if a careful study is made of the veining. Sometimes leaf gold or bronze powder is used on the veins, but the practice is not one to be recommended. *See* MARBLING.

Gold Compounds (*Chem.*) AUROUS OXIDE, Au_2O, is a green powder obtained by the action of caustic potash on aurous chloride. AURIC OXIDE, Au_2O_3, forms a brown powder when dry, decomposed by light, also on heating. It dissolves in alkalis, forming AURATES, *e.g.* $KAuO_2$. It may be obtained by adding an alkali in excess to auric chloride, and reducing with sulphurous acid. With ammonia it gives fulminating gold (*q.v.*) AUROUS CHLORIDE, AuCl, is a pale yellow powder insoluble in water, obtained by heating the trichloride at its melting point. Boiled with water it yields gold and the trichloride. It is easily decomposed into its elements on heating. AURIC CHLORIDE, $AuCl_3$ (CHLORIDE OF GOLD), when volatilised, forms "large thin red crystals, very like rubies, and glorious to behold, which would run in the air, *per deliquium*" (BOYLE); melts at 288° and decomposes in air into the aurous chloride. "The decomposition . . . in air might be expected to become perceptible at 70°, requiring, however, about twenty-five years for its nearly complete change into the monochloride" (ROSE). It is very soluble in water, alcohol, and ether. Water containing organic matter reduces it. It may be prepared by dissolving gold in aqua regia; evaporating the solution, which is chloro-auric acid, $HAuCl_4$, and very gently heating to expel the hydrochloric acid. Its solution mixed with sodium thiosulphate forms sodium aurous thiosulphate, $Na_3Au(S_2O_3)_2$—a solution used in photography. Gold chloride also unites with the hydrochlorides of many organic bases, forming characteristic double salts. *See also* PURPLE OF CASSIUS.

Gold Cushion (*Binding*). A flat board on which a couple of thicknesses of flannel are laid, the whole being covered with a piece of calfskin, the rough side up. It is used to cut the gold leaf upon.

Golden Number (*Astron.*) The number of a year in the Metonic Cycle. *See* METONIC CYCLE.

Gold Leaf (*Dec.*) Is sold in a variety of qualities and colours, and, for the purposes of the gilder, is usually put up in "books," *i.e.* interleaved with paper sewn at one side, measuring 3¼ in. square, and containing twenty-five leaves of gold. In calculating the quantity of gold leaf required, it is usual to take the area as a square of 3 in., so as to allow for waste. Leaf gold is applied to a surface of gold size, when nearly dry, by means of a "tip" (*q.v.*), and adheres closely to the surface. An American system of gilding by means of long ribbons or strips of gold rolled round a small cylinder, and applied by means of a simple appliance, is growing rapidly in favour among railway carriage builders, decorators, and yacht builders.

Gold Leaf Electroscope (*Elect.*) Consists usually of two rectangular pieces of gold leaf attached to the end of a conducting rod, insulated by ebonite, glass, or, better, sulphur or paraffin wax, and screened from air currents by a glass case or shade. A charge of electricity given to the rod (either by contact or induction) causes the leaves to diverge.

Gold Paints (*Dec.*) Originally these were gold leaf ground up with some medium. They are now really bronze powders suspended in a varnish or other quick drying medium. The bronzes are alloys of copper and tin, and, owing to climatic conditions, they have to be made abroad. The brightness of the paint depends on the skill in making the bronze and the use of a medium which has no solvent action on the bronze alloy.

Goldschmidt's Process (*Chem.*) Goldschmidt, requiring some aluminium sulphide, found he could easily prepare this compound by igniting a mixture of galena (PbS) and aluminium powder. A violent reaction occurred, and he obtained lead and aluminium sulphide. Similarly from ferrous sulphide and aluminium powder he could easily obtain aluminium sulphide and metallic iron. He then examined the action of powdered aluminium on various metallic oxides, and found that on account of the enormous heat of formation of aluminium oxide, the aluminium could reduce all oxides except that of magnesium. To reduce an oxide, the latter, in the form of powder, is mixed with powdered aluminium in slight excess, and the mixture placed in a crucible. When the reduction is easy, the reaction can be started by a piece of magnesium ribbon, which is stuck into the mixture and ignited; when the reduction is more difficult, as in the case of chromium oxide, a cartridge of barium dioxide and aluminium powder is made,

and magnesium ribbon is inserted in this. It is estimated that the temperature attained in these reductions is about 3000°. The reduced metals form fused masses at the bottom of the crucible. In the case of chromium the slag contains minute rubies (Al_2O_3) coloured by chromium. Besides finding extensive use in the reduction of metals, the process has been applied to soldering iron pipes where a very high temperature is required.

Gold Size (*Dec.*) *See* JAPANNER'S GOLD SIZE, WATER GOLD SIZE, *and* MATT GOLD SIZE.

Gombron Ware (*Pot.*) A Perso-Chinese ware of a semi-porcelain character, creamy white in colour. It was so called because imported from Gombroon (Bender-Abbasi) in Persia, in the seventeenth century. An imitation of this ware was made in Chelsea.

Gonfalon. A banner suspended from a cross bar attached to a pole. The banner generally terminates in several pointed streamers.

Gonfannon (*Archæol.*) A pennon or small flag attached to a knight's lance immediately below the head.

Gong (*Clocks, Watches*). A steel wire coiled into a flat spiral form, used in clocks and repeating watches in place of a bell.

Goniometer (*Min.*) An instrument for measuring angles. There are two patterns, CONTACT and REFLECTING goniometers. In the contact goniometer two hinged metal bars are adjusted in contact with the faces whose angle of inclination is to be measured, and the angle read off on a divided circle attached. The angle is usually read as the angle between the normals of the faces, *i.e.* 180° less the dihedral angle between the faces. In the reflecting goniometer the edge between the two faces is adjusted to lie in the axis of rotation of the divided circle; the crystal is then rotated till one face reflects light from a distant signal through a reading telescope; the axle bearing the crystal is now clamped to the divided circle as it stands at zero, and the now fixed pair of wheels rotated till the signal is seen in the second face, when the angle between the faces is read off on the divided circle, again as the angle between the normals. The reflecting goniometer was introduced by Wollaston, and often bears his name.

Gooch's Link Motion (*Eng.*) *See* LINK MOTION.

Good Colour (*Print.*) A term used to imply that the result of the impression is good, the ink having been evenly and satisfactorily applied to the sheet.

Goods (*Chem. Eng.*) A general term applied to the raw oils, fats, and greases used in soapmaking; sometimes called "stock," though the latter may be bleached or partially saponified material.

Gordon's Formula (*Eng.*) An empirical formula due originally to Navier, by which the load which may be applied to a strut or column may be calculated. Let W be the load, A the area of cross section, l the length, h the thickness of the column, f the Proof Stress (*q.v.*), n a numerical constant, such that the Moment of Inertia, I (*q.v.*), of the cross section is equal to nAh^2, and c a second numerical constant, usully determined by experiment; then

$$W = A \frac{f}{1 + \frac{l^2}{cnh^2}}$$

If the column be short, so that the ratio $\frac{l}{h}$ is small, this becomes $W = Af$. If the column be long, the formula reduces to

$$W = \frac{cnh^2}{l^2} Af$$

$$= \frac{c}{l^2} I f.$$

Gorged (*Her.*) Having a collar round the neck. Many heraldic beasts are "gorged," also the supporters of the shield.

Gorget (*Armour*). A piece of armour worn in the fifteenth and sixteenth centuries, and forming a junction between the helmet and the cuirass. *See* ARMOUR.

Gorgoneion (*Art*). A representation of the Gorgon's head, one of the three mythical personages whose hair consisted of snakes and whose look turned the beholder into stone.

Goslarite (*Min.*) A hydrous sulphate of zinc, $ZnSO_4 . 7H_2O$. Oxide of zinc = 28·2, sulphuric acid = 27·9, water = 43·9 per cent. Rhombic; also massive and incrusting. White. Soluble in water. It occurs as a rarity in Cornwall and Anglesea, but chiefly in the Harz. Also from Sweden, Austria, and Hungary.

Gothic (*Typog.*) A bold faced antique type similar in appearance to black letter, used in jobbing work.

Gothic Architecture. The name applied, originally as a term of reproach, to the architecture of Western Europe from about 1150 A.D. to 1500 A.D. The principles of concentration of strain and of balancing thrusts by counterthrusts which underlie Gothic architecture led to the use of the pointed arch and the ribbed vault, two characteristic features of the style. *See* CURVILINEAR, DECORATED, EARLY ENGLISH, *and* PERPENDICULAR.

Göthite (*Min.*) Hydrated ferric oxide, $Fe_2O_3 . H_2O$. Ferric oxide = 85, water about 11 per cent., with usually some silica and manganese. Rhombic; often in flattened prisms; more often fibrous. Colours, yellow-brown to a deep blue-black. Streak (*q.v.*), a yellow brown. Often in minute crystals associated with quartz. From Cornwall, Cumberland, Prussia, United States, etc.

Go Through Machine (*Lace Manufac.*) A twist lace machine in which the principle actuating the carriages is such that they go through without any pause. Invented by Alcock of Worcester in 1835 and called the CAMEL MOTION.

Gouache (*Paint.*) A method of watercolour painting with opaque colours mixed with water, gum, and honey. A great deal of the illustrations in mediæval missals were executed in Gouache. In painting on paper the whole of the surface is covered, as in oil painting, the lights being laid in afterwards.

Gouge (*Carp., etc.*) A cutting tool similar in principle to a chisel, but having a blade whose cross section is a circular arc. PARING and SCRIBING GOUGES have the bevel on the concave side; TURNING and FIRMER GOUGES have the bevel on the outer or convex side; the latter is the more common form.

—— (*Bind.*) A brass gilding tool with a curved end, often semicircular. Gouges are made in sets, are of different diameters, and are extremely useful in working out designs on book sides.

Gouge (*Forge*). A hollowed tool used in smiths' work; usually held by a handle and struck by a sledge hammer.

Gouge Bit (*Carp.*) A boring tool or bit in the shape of a gouge, without any central point or cutting lip.

Gouge Slip (*Carp., etc.*) A thin piece of oilstone, etc., with a rounded edge; used in setting and sharpening gouges.

Gouttes (*Her.*) *See* GUTTÉE.

Governing Motion (*Cotton Manufac.*) An attachment to the mule for regulating the tension of the threads as they are wound on during the formation of the copbottoms. Sometimes termed the STRAPPING MOTION.

Governor (*Gasfitting*). An apparatus for regulating the pressure of gas. *See* GAS REGULATOR.

Governors (*Eng.*) A governor is an automatic mechanical device for controlling the speed of a steam engine, gas engine, or other prime mover; it serves, to some extent, the same purpose as the pendulum of a clock. In the original form, due to Watt, it consisted essentially of a spindle A (fig. 1), which is caused to rotate by the engine at a speed which varies with the speed of the crank shaft. Two heavy balls B, B are hinged to A by two arms C, C, which are connected by links D, D to a collar or sleeve E which can move up and down the spindle A. This sleeve is connected by a system of levers F, G, to the THROTTLE VALVE (*q.v.*) of the engine, so that E opens the valve as it falls, and closes it again as it rises. An increase in the speed of the engine causes the balls to fly outward and raise the sleeve E, which acts on the throttle valve and partially cuts off the supply of steam until the speed falls to its normal value; if the speed fall below the normal value, the throttle valve is opened more widely, and the engine gains speed. There are many modifications of this simple form of governor.

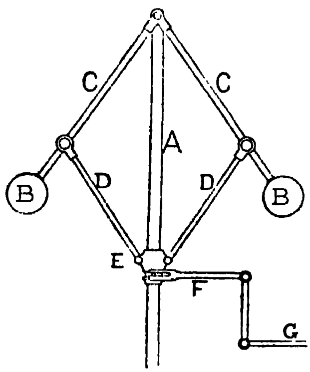


FIG. 1.

A LOADED GOVERNOR (fig. 2) has a heavy mass M attached to the sleeve E; it is suitable for higher speeds than the simple form. A CROSSED ARM GOVERNOR (fig. 3) has the arms hinged to a cross-piece at the top of the spindle A, so that the joints of the arms and the balls are on opposite sides of the spindle A. If the centres on which the two arms turn be properly chosen, the governor is practially ISOCHRONOUS; that is the governor remains very steady at one fixed speed, but a very slight alteration will cause the balls to fly to their highest or lowest point, according as the speed has increased or diminished. A strictly isochronous governor would be too sensitive for convenience, as it would cause HUNTING or over-correction of the speed: *i.e.* when the governor was acting so as to increase the speed, it would increase it too much; this would lead to a sudden change in the opposite sense, and so on. In certain cases a governor is fixed on the main shaft, with loaded arms moving in a vertical plane. One such form is shown in fig. 4. The main shaft A carries a circular case or frame B; two heavy masses C, C are fixed to the frame by pivots at D, D, and are kept in a position of equilibrium by springs E, E. An increase of speed causes the arms to fly outwards, and their motion is communicated by links F, F to a lever G. The motion of G is communicated to the throttle valve (or other controlling device) by means of a system of levers or other mechanism. A gas engine generally has a governor of the ordinary type; but instead of acting on a throttle valve, it usually causes the engine to miss one or more explosions when the speed rises above a certain limit. Various types of governor have also been invented which control the character of the mixture, *i.e.* which alter the relative proportions of air and inflammable gas in the charge; but the simpler arrangement is found to be more satisfactory.

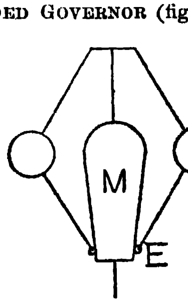


FIG. 2.

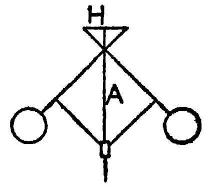


FIG. 3.

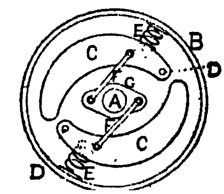


FIG. 4.

Grab (*Eng.*) A mechanical excavator or steam navvy, the essential part consisting of a steel bucket opening in two halves like jaws, the bucket being lowered and raised by levers or chains actuated by a form of crane. The jaws are opened automatically as the bucket is lowered; when the latter strikes the surface of earth, sand, mud, or other loose material, it sinks in for a certain distance. The jaws are then forced together mechanically, and the bucket with the enclosed material raised.

Grace Cup. A loving cup. The custom of handing round a large cup filled with wine after grace has been said came into vogue early in the Middle Ages.

Gradient (*Civil Eng.*) The slope of a road or railway. The RULING GRADIENT is the greatest slope allowed on any particular line; it varies with circumstances. In railways in mountainous districts it may reach 1 in 25, which is generally regarded as the limit for locomotives with smooth wheels, depending on the adhesion between the wheels and the rails. Higher gradients require the use of a toothed rack or some equivalent device. *See* FELL RAILWAY *and* MOUNTAIN RAILWAYS.

——, **Barometric** (*Met.*) The steepness of the slope of isobaric surfaces. This steepness is measured by the difference in barometric pressure along the same level. *See* ISOBAR.

Gradine (*Architect.*) A step or low steplike seat forming one of a series, *e.g.* the seat in an amphitheatre; also a shelf at the back of an altar.

—— (*Sculp.*) A toothed chisel.

Grading (*Cotton Manufac.*) A system of classifying cotton to determine its quality and value. A rough classification is as follows:

American.	*Brazilian.*	*Egyptian.*	*Indian.*
Good ordinary.	Mid. Fair.	Fair.	Fair.
Low Middling.	Fair.	Good Fair.	Good Fair.
Middling.	Good Fair	Good.	Good.
Good Middling.			Fine.
Mid. Fair.			

The first mentioned are the lowest qualities in each case.

Gradometer (*Surveying*). An instrument for measuring the angle of dip of a rock formation or mineral deposit.

Graduation Towers (*Chem. Eng.*) Stacks of brushwood used for the natural evaporation of brine in the manufacture of salt. Used in Continental practice only.

Graffito, *pl.* **Graffiti** (*Archæol.*) A drawing or writing scratched on a wall or other surface; notable examples are to be found in Egyptian tombs, Pompeii, Rome, etc. *See also* SGRAFFITO.

Graham's Law (*Chem.*) Gases diffuse at a rate which varies inversely as the square roots of their densities. *See* DIFFUSION.

Graham's Mecurial Pendulum. *See* PENDULUMS.

Grain. *See* WEIGHTS AND MEASURES.

Grain. The fibrous structure of wood or of certain metals, or various other substances. The expression "with the grain" means along the direction of the fibres; "across the grain" or "cross grain" means a direction more or less at right angles to them.

Graining (*Chem. Eng.*) *See* CUTTING.

—— (*Dec.*) The art of imitating by means of oil or water paint the grain of wood. *See also* MARBLING. Formerly graining was used to a considerable extent in finishing the woodwork of dwelling houses and other buildings, but of late years it has almost ceased to be used excepting in country districts, coloured paint work having largely taken its place. Graining possesses the advantage of being the most durable class of paint work, and when covered with a good varnish it is very suitable for kitchens, passages, and other places subjected to great wear. Although graining has been condemned by Ruskin and other writers as a sham, its convenience and durability render it likely to remain in use for many years. The tendency at the present time is toward an increase in the use of graining. If properly executed in appropriate positions, it does not offend artistic taste. Sometimes, however, the grainer places his work in situations altogether inappropriate; for example, on a solid cast iron or steel column supporting a beam. In such a case, if the column is grained to represent wood the effect is bad, because if the column were actually made of wood it would obviously break under the strain imposed upon it. In steamboats and other vessels graining is also used without due thought, as, for instance, on metal linings. The safe rule to follow is that graining can be employed in any situation where the surface grained might actually be constructed of the wood that is imitated. In all cases the surface of the work it is intended to grain should be prepared precisely in the same way as for ordinary painting, four coats being generally given on new work. The final coat should be the lightest colour of the wood to be imitated. The surface must be quite solid and level, free from any absorbent quality. The grounds should be rich and warm in tone, but not too bright or glaring. A little less oil than usual may be used in the last coat. The principal GRAINING GROUNDS are prepared as follows: *Ash:* This ground is best made of white lead tinted with a very little vermilion and sufficient lemon chrome. Yellow ochre may be used lightened with lead. *Antique Oak:* White lead tinted with French ochre, burnt umber, and Ventian red gives a good antique oak ground which must be kept quite dark. *American Walnut:* White lead tinted with French ochre, burnt umber, and Venetian red gives this ground, which is practically the same as the ground intended for antique oak, but many grainers prefer to add burnt sienna. *Birch:* White lead, to which has been added a little yellow ochre, produces a good birch ground. White lead, French ochre, and a little yellow chrome are sometimes preferred. *Dark Oak:* White lead mixed with a little golden ochre gives a good ground, and a little Venetian red and burnt umber may be added if desired. *Light Oak:* White lead and yellow ochre, to which has been added a little lemon chrome, if desired. *Maple:* White lead should be tinted with vermilion and a little lemon chrome. *Medium Oak:* French ochre and white lead with a little burnt umber give this ground. *Mahogany:* Venetian red, orange, chrome yellow, and burnt umber give a dark mahogany ground which may be lightened if desired by the addition of white lead. *Pitch Pine:* Venetian red and white lead with a little French ochre. *Satinwood:* Lemon chrome and white lead with a very little English vermilion give this ground. *Knotted Oak:* White lead, French ochre, and burnt umber. *Rosewood:* Same as dark mahogany. Upon the surface, when thoroughly dry, the graining colour is painted. This colour varies in composition with the wood to be imitated. It is usually somewhat thin and transparent, and is applied with a brush in streaks. The graining colour is partly removed by means of steel combs with teeth of varying width, and also by means of a cloth held over a thumbpiece of horn, shaped for the purpose. The following GRAINING COLOURS are chiefly used. *Ash:* Same as light oak *American Walnut:* Burnt umber and a little Vandyke brown. *Birdseye Maple:* Raw umber and raw sienna toned down with a little Vandyke brown or ivory black. *Cherry:* Raw sienna and burnt sienna and raw umber. *Chestnut:* Raw sienna, Vandyke brown, and raw umber, to which may be added a little burnt sienna. *Mahogany:* Burnt umber, burnt sienna, and Vandyke brown. *Rosewood:* Vandyke brown, with the addition of a little black. *Light Oak:* Burnt umber and raw sienna, to which is added a very little black. The ground having been painted over with the graining colour, the grainer proceeds as follows: In the case of oak he draws the comb along those portions of the work, such as the stiles and rails in a door, which are likely to be a straight grain, thus imitating it very quickly and in a simple manner. The panels, however, are supposed to be cut out of a different part of the log of wood, and in this case it is necessary to put in the light marks known as "champs." When the whole of the work has been imitated by removing part of the colour, it is usually "overgrained" with colour ground in water; a little blue black is frequently used. This is laid on with a hoghair brush, known as an "overgrainer," and softened with a badger hairbrush, so as to produce the difference of light and shade in the various

parts. Stale beer, gum, glycerine, or Fuller's earth are added to bind the overgraining colour. Mahogany is grained by wiping off larger portions of the graining colour and softening one part into the other. The various processes of graining the different woods are too lengthy and of too technical a description to be described here. In some cases a roller is finally passed over the work. These rollers consist of a number of discs with notched edges, which revolve against a brush charged with a dark water colour, the result being a number of irregular dotted lines over the face of the work. Various mechanical methods are also used for graining. The most commonly used is what is known as transfer graining paper. This consists of paper having on it the grain of the wood printed in distemper colour, which can be transferred on the paper being dampened. There is a stiffness in appearance in this class of work which stands in the way of its being used very extensively; but if care is taken to blend the pattern before it is dry, a very creditable job may be made of it. Another mechanical method consists of graining with a material known as "Gransorbian," which is like thick blotting paper. This is pressed against the wet graining colour, thus producing an appearance like the grain of wood. Rollers having the grain in relief are also used for cheap work, but the repetition of the pattern stands in the way of their being used for anything except the very commonest work. The test of all graining is how near it approaches to the actual wood in appearance. Students in graining usually copy from choice specimens of wood, so as to get the appearance produced by nature.—A. S. J.

Graining (*Leather Manufac.*) A fictitious grain may be imparted to a skin by passing it through the rollers on which the grain markings are engraved. A sheepskin is frequently printed with a goat grain or even with alligator, crocodile, or pigskin grain. *See also* BOARDING.

Graining Boards (*Binding*). Beech or pear tree boards cut in *intaglio* with different designs, and used to impress patterns on the sides of whole bound calf books by pressure.

Grain Leather. Leather dressed with the grain side outwards.

Grain Side (*Leather Manufac.*) The side of the skin on which the hair grew.

Grains of Paradise. The pungent aromatic seeds of *Amomum melegueta* (order, *Zingiberaceæ*), known also as GUINEA GRAINS, have been used as an adulterant of beer and spirits.

Grain Split (*Leather Manufac.*) *See* BAG HIDES.

Grain Tin (*Met.*) Tin of the purest quality, produced by heating refined tin to a temperature rather below the melting point. At this temperature it is very brittle, and is broken up either by a hammer or by being dropped from a height.

Gram. *See* WEIGHTS AND MEASURES.

Gramineæ (*Botany*). The grasses form a large order of *Monocotyledons*; they vary in habit and structure from the annual herbaceous grasses to the giant bamboos. Their economic importance is well known.

Gramme Armature (*Elect. Eng.*) The early form of RING ARMATURE. *See* ARMATURES.

Gram Molecule (*Chem.*) The molecular weight of a substance taken in grams, *e.g.* a solution containing a gram molecule of cane sugar is one containing 342 (the molecular weight of cane sugar) grams of cane sugar.

Granite (*Geol.*) A name for a group of rocks which have slowly consolidated from a fluid state under enormous pressure, and which consist essentially of a granular holocrystalline aggregate of alkali-felspars and quartz, with or without accessory minerals of other kinds. The constituents normally occur in such a manner as to show that each mineral in consolidating has grown so as to hinder its neighbours from assuming the crystalline boundaries proper to the species; in other words, the structure is granitic, and the constituents are allotriomorphic with respect to each other.

Granite Weaves (*Woollen Manufac.*) Small weaves or schemes of interlacing warp and weft, giving indefinite patterns.

Granitic Structure (*Geol.*) This is due to the conditions of pressure and temperature which prevailed when the rock exhibiting it was undergoing consolidation. Each separate mineral constituent has grown in such a manner as to prevent the crystals adjoining it from assuming their own proper bounding planes. Minerals which behave thus are said to be allotriomorphic with respect to each other. In granitic structures, therefore, the mass is holocrystalline, and the mineral constituents are allotriomorphic. The structure characterises granite, syenite, diorite, gabbro, and some few other rocks of eruptive and deep seated origin.

Granolith, Stuart's. *See* ARTIFICIAL STONE.

Granophyre (*Geol.*) A name formerly used for certain types of granite in which some of the quartz and felspar show the curious intergrowth which characterises GRAPHIC GRANITE. These granophyric granites appear to have been formed at lesser depths than granite of the normal kind. In some cases they appear as if they had originated through the solution of an older basic rock by the action of a magma containing much potash and silica, and the subsequent recrystallisation of the compound deep within the core of a full grown volcano.

Grant Reel (*Silk Manufac.*) A particular form of reel which enables the skein to be wound more fully and economically. To form the skein, the thread passes on to a reel, as in ordinary reeling; but owing to the traverse motion being regulated by a particular multiple of wheels the traverse is laid on in diamond form, thus creating spaces which are afterwards intersected with lacing thread to retain the cross or traverse.

Granular Iron (*Met.*) Iron whose fractured surface shows a regular granular structure. This denotes a good quality of metal.

Grape Seed Oil. Made from the seeds of grapes removed from the fruit during the preparatory process of brandy making. The seeds are ground, and when expressed yield a thick yellow oil, which may be used for cooking purposes, as a substitute for olive oil, and in soap and varnish making. The supply, however, is very limited.

Grape Sugar (*Chem.*) Another name for DEXTROSE (*q.v.*)

Graph. A curve showing the relation between two variables, *e.g.* a curve showing the height of the

barometer throughout the day. Graphs are "plotted" or drawn either from two sets of observations or from an equation which expresses the relation between the two variable quantities.

Graphic Calculation (*Mech.*, *Phys.*, *etc.*) The calculation of numerical results based upon the representation of quantities by lines. The most important example is furnished by GRAPHIC STATICS (*q.v.*)

Graphic Formulæ (*Chem.*) *See* CHEMICAL FORMULÆ.

Graphic Granite (*Geol.*) A granite (*q.v.*) in which the quartz and the felspar have simultaneously intergrown with each other. The component minerals form, in consequence, a series of markings, bearing a fancied resemblance to written characters.

Graphic Statics. The calculation of the forces acting on structures (roofs, bridges, etc.) can be carried out very much more easily by graphic methods (*i.e.* by drawings made to scale) than by abstract calculations. The graphic method is based chiefly on the theorem known as the POLYGON OF FORCES, which may be stated as follows: If any number of forces act at a point in a body which remains at rest under their action (that is, if the forces are in equilibrium), then the forces can be represented in magnitude and direction by the sides of a polygon taken in order. Thus if the lines 1, 2, 3, 4, 5 (fig. 1) represent forces acting at a given point, then these forces may be represented by the lines 1, 2, 3, 4, 5 in fig. 2, each line being parallel to the direction of the force which it represents, and of length proportional to that force. Fig. 1 is often termed the FORCE DIAGRAM; fig. 2 is the POLYGON OF FORCES which

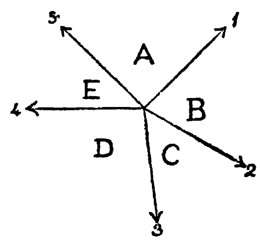


FIG. 1.

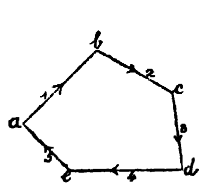


FIG. 2.

corresponds to it. The most convenient way of naming these forces is by means of BOW'S NOTATION. Letters A, B, C, D, E are placed as shown, and the force 1, which acts along the line separating the space A from the space B, is termed the force AB. In the polygon (fig. 2) the line parallel to AB is marked *ab*, the letters being placed at the ends of the line. Fig. 2 is a figure whose sides are respec-

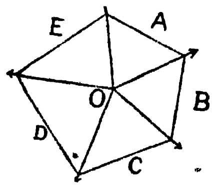


FIG. 3.

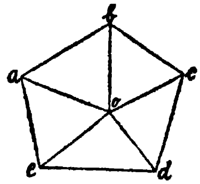


FIG. 4.

tively parallel to the lines in the first figure, and is said to be the RECIPROCAL FIGURE to fig. 1. If any point *o* be taken, and lines *oa*, *ob*, *oc*, *od*, *oe* (fig. 4) be drawn to the angles of a polygon of forces, the figure so formed is termed a POLAR DIAGRAM, and the point *o* is termed its POLE. If now a reciprocal figure to the polar diagram be drawn in conjunction with the original diagram showing the direction of the forces, or FORCE DIAGRAM (fig. 1), in such a way that a line parallel to *oa* is drawn across the space A (in any convenient position), a second line, starting from the end of this, across the space B and parallel to *ob*, and so on, we get the figure called the FUNICULAR POLYGON (fig. 3). For any system of forces in equilibrium, the funicular polygon is a closed figure, whatever be the position of the POLE *o*. This statement is true whether the forces act at a point or not. If we are given a system of forces which are not in equilibrium, we can find the magnitude, direction, and position of the force necessary to keep the system in equilibrium. The Polygon of Forces will give us the magnitude and direction of this force or Equilibrant; the Funicular Polygon will give a point on its line of action, from which we can find its point of application. The force is therefore completely determined. The following example indicates the method of finding this force or EQUILIBRANT for a system of parallel forces, such as those of a loaded beam. Let the forces act along parallel lines represented in Bow's Notation by AB, BC, CD, DE (fig. 5), and in magnitude and direction by *ab*, *bc*, *cd*, *de* (fig. 6), each of these lines being proportional to the magnitude of the force which it represents. Draw the Polar Diagram from any pole *o* (fig. 6), and in the spaces B, C, D draw lines parallel to *ob*, *oc*, *od*. Now let lines in the spaces A and D be drawn parallel to *oa* and *od*, and produced till they meet. The point where they meet will be

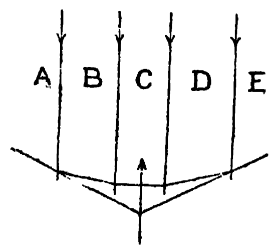


FIG. 5.

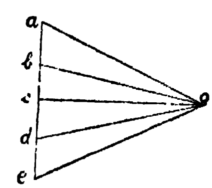


FIG. 6.

the point where an upward force, equal in magnitude to *ae* (the sum of the loads AB, BC, etc.), and in a direction parallel to *ac* (and therefore to AB, BC, etc.), must be applied, in order to balance the downward forces. In such a case as this, where the forces are parallel and in the same direction, the figure *abcde*, or Polygon of Forces, becomes a straight line; it is then usually termed the LINE OF LOADS.

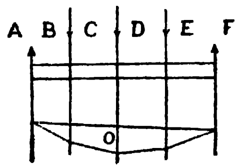


FIG. 7.

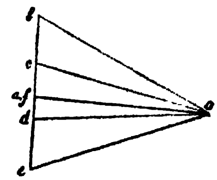


FIG. 8.

The Funicular Polygon is also applied in finding the forces required to be applied to support a loaded beam, that is the REACTIONS AT THE SUPPORTS,

Let BC, CD, DE (fig. 7) be the loads, acting downwards, and let AB and EF be the position of the reactions. Draw the line of loads *bcde* (fig. 8) and the polar diagram from the pole *o*. Construct the Funicular Polygon by lines in the spaces B, C, D, and E parallel respectively to *ob*, *oc*, *od*, and *oe*. Draw the closing line of the Funicular Polygon, as shown by the heavy line, and from *o* draw a line *oa* parallel to this closing line, cutting the line of loads in the point *a*. Then *ba* represents the reaction at AB, and *ea* (or, as it may be marked, *ef*) the reaction at EF. The above is one of the most simple cases; but graphic methods are applicable to very complicated cases of framed structures, such as iron bridges, built up girders, roofs, cranes, etc. Wind pressure in roofs, oblique reactions at the supports, the effect of ceiling loads, and numerous other effects can readily be calculated by methods based entirely on the fundamental principles enunciated above.

Graphic Tellurium (*Min.*) A telluride of gold and silver, $(Au.Ag)Te_2$. The gold and silver equal about 40 per cent. together. It occurs grey or silver white crystals with a high metallic lustre, arranged in lines so as to give some resemblance to writing; hence the name. Also called SYLVANITE. From Transylvania and California. It is a very valuable ore of gold when in sufficient quantity.

Graphite. Carbon: hexagonal. Also called Plumbago and Blacklead. Occurs usually in foliated masses, sometimes in hexagonal plates, in metamorphic rocks chiefly. It is one of the few minerals which leave a shining black streak when rubbed on paper. From Cumberland, India, Ceylon, Bohemia, etc. It is used to make pencils, to form a conducting coating of moulds in electrotyping, etc.; as a lubricant (*e.g.* for wood surfaces and cycle chains), and as blacking (*q.v.*) for moulds in the foundry.

Graphitic Carbon (*Met.*) The carbon which is mechanically diffused in pig iron, as opposed to combined carbon. It gives the characteristic crystalline fracture to grey pig iron. *See* KISH.

Grass (*Mining*). The surface of the ground above the mine. BROUGHT TO GRASS means raised to the surface.

Grassing (*Linen Manufac.*) After retting (*q.v.*) the flax straw is spread over grass fields to get the sun and air and complete the retting process, and during the process of bleaching also the yarn or cloth is spread on grass fields. This assists to whiten it, and avoids the necessity of using strong chemicals. This spreading is called "grassing."

Grass Wrack (*Botany*). A submerged marine flowering plant, *Zostera marina* (order, *Naiadaceæ*) common on the shores of Britain. The dried plant is much used for packing glass and for stuffing cushions and mattresses.

Grate (*Eng., etc.*) The portion of a furnace or firebox which supports the fuel during combustion.

Grate Area (*Eng.*) The surface required to burn enough coal to produce the power at which the boiler is to be worked: it is usual to quote the amount of surface needed to consume 1 lb. of coal, the number of pounds of coal being determined by the horse power required.

Grating (*Phys.*) A surface ruled with very fine lines (5,000 to 40,000 per inch), used to produce DIFFRACTION SPECTRA (*q.v.*) The ruling may be on a glass plate (TRANSMISSION GRATING) or on a reflecting surface (REFLECTION GRATING). *See* DIFFRACTION GRATING.

Grating (*Build.*) The perforated cover of a gully, etc.

Grave (*Music.*) Slow: heavily.

Grave Accent (*Typog.*) A sign placed over a letter thus, è.

Gravel (*Geol.*) A term usually restricted to any loose accumulation of subangular stones which have been worn and sorted by the action of running water, especially by that of a river. Similar accumulations which have been more completely rounded are often distinguished as SHINGLE. In the south of England the term is usually understood to mean "flint gravel," in which the stones are more angular than is usual.

Graver. A tool used in hand turning, consisting of a steel blade of square section, with the end ground off diagonally so as to produce a rhombus, the outer edges of which constitute the cutting edges of the tool: the pointed end is also utilised.

—— (*Engrav.*) *See* BURIN.

Graving Dock (*Civil Eng.*) A small dock (usually large enough to contain one vessel) which can be emptied of water to enable repairs to the ship's bottom to be carried out. The dock is of such depth that on admitting water at high tide a vessel can be floated in or out with ease.

Gravitational Astronomy. The dynamical theory of the heavenly bodies, dealing with their attraction on one another, their masses, etc.

Gravitation, Gravity (*Phys.*) The force with which one mass attracts another; in particular the force of attraction exerted by the Earth on a body, or the force exerted by one planet or other celestial body on another. The actual attraction between two bodies on the Earth's surface is very minute and can only be detected by special apparatus of great delicacy. The mathematical expression for the force f between two particles of mass m_1 and m_2, separated by a distance d, is $f = \frac{\quad}{d^2}$ The constant k is termed the CONSTANT OF GRAVITATION: its value is about $6{\cdot}6576 \times 10^{-8}$ in centimetre gram second units. Thus two small particles, each having a mass of 1 gram, placed 1 centimetre apart, would attract each other with a force of $6{\cdot}6576 \times 10^{-8}$ dynes. From the same constant it is possible to calculate the total mass of the Earth, and thence its density, which is found to be 5·527 times that of water.

Gravity, Centre of. *See* CENTRE OF GRAVITY.

Gravity Escapement (*Clocks*). A clock escapement in which the vibrations of the pendulum are sustained by the fall of the gravity arm through a constant height. *See* ESCAPEMENT.

Grazioso (*Music*). *See* CON GRAZIA.

Grease. The rendered or melted fat of animals; oily matter, especially as used in various manufactures and as a lubricant. *See* CANDLES *and* SOAP.

Grease Box (*Eng.*) A hollow box immediately above the axle bearing of a locomotive or truck, containing grease for lubricating the bearing.

Grease Traps (*Hygiene*). It is necessary in the case of hotels, clubs, etc., that special means be adopted for receiving the discharges from the scullery sink waste pipes. The ordinary gully traps are not suitable for this purpose, as the fatty matter solidifies on entering, and causes obstruction in the drains. The evil can be corrected either by fixing a trap which collects the grease and from which it can be removed by hand, or by adopting an appliance

where the solidified grease can be broken up before entering the drain. The latter method is preferable. In an efficient grease trap there should be (1) a good body of water: this rapidly cools the grease, causing solidification; and (2) a discharge from an automatic flush tank should be connected with the trap, by means of which the congealed mass is broken up and can then pass into the drains.

Great Circle (*Astron.*) The line on the surface of a sphere formed by the intersection of a plane passing through the centre of the sphere.

Great Millet (*Botany*). *See* DHURRA.

Great Organ (*Music*). That part of the organ having the heaviest stops. In two-manual instruments the great keyboard is the lower, and in three, four, or five manuals it is the lowest but one.

Great Primer (*Typog.*) Type one size smaller than Paragon. *See* TYPE.

Great Wheel (*Watches, Clocks*). The first or main wheel of a watch or clock. Usually the largest wheel in the train and the nearest to the weight or spring. It is the first of the series of agents transmitting energy from the weight or spring to the escapement. *See* TRAIN.

Greaves (*Armour*). Armour forming a covering for the legs below the knee. Greaves were worn by ancient nations as well as in the Middle Ages. *Cf.* JAMBART *under* ARMOUR.

Greaves *or* **Graves.** Animal tissue left after melting off fat at a high temperature. The greaves are usually pressed for a further supply of fat, and finally formed into cakes as food for dogs, swine, etc.

Greek Architecture. The trabeated style of architecture which obtained in Greece, Sicily, and Asia Minor. The principal buildings of note were erected during a period commencing about 650 B.C. and ending about 100 B.C.; the great masterpieces of Greek art were constructed between the years 460 B.C. and 400 B.C. The latter period is known as the Periclean age, as it was during the administration of Pericles that Ictimas and Callicrates designed the Parthenon, the sculpture of which was executed by Phidias. *See* ARCHITECTURE, ORDERS OF, *and* ROMAN ARCHITECTURE.

Green. *See* COLOURS (PIGMENTS, DECORATIONS, *etc.*) *and* BRUNSWICK GREEN, CHROME GREEN, EMERALD GREEN, MINERAL GREEN, *etc.*

Green Bricks. *See* BRICKS.

Green Carbonate of Copper (*Min.*) A synonym for MALACHITE (*q.v.*)

Green Fog (*Photo.*) This is a dichroic fog, being green by reflected light and red or pink by transmitted light. It is very frequently seen on negatives taken on orthochromatic plates, more especially when ammonia has been used in the developer.

Greenheart. *See* WOODS.

Green Liquor (*Chem.*) The liquor left from the bleaching of palm oil by the bichromate process. It is sometimes treated to recover the chromium it contains.

Greenockite (*Min.*) Cadmium sulphide, CdS. Cadmium = 77·7, sulphur = 22·3 per cent. In hexagonal yellow crystals, with the two terminations different (hemimorphic). Also rarely as an incrustation on zinc blendes; *e.g.* from Wanlockhead in Dumfriesshire. Chiefly from the Bishopstown tunnel in Dumbartonshire; also from Bohemia, Greece, and Pennsylvania.

Green Oil (*Chem. Eng.*) (1) The second fraction which comes over in the distillation of Yorkshire grease. Occasionally used for coarse lubricating greases, but usually reworked with another batch of grease. (2) A product in GAS MANUFACTURE (*q.v.*)

Greensand (*Geol.*) In the geological sense GREENSAND is usually understood to mean the rocks which lie between the Chalk and the Gault (the UPPER GREENSAND) and those which lie between the Gault and the Wealden Beds (the LOWER GREENSAND). In both cases the name was given because the presence of grains of Glauconite imparts a greenish colour to the sands of these formations. Both are important sources of water supply in the south east of England.

Green Sand (*Moulding*). Moist foundry sand, as distinguished from sand which has been mixed with clay, etc., to form loam (*q.v.*), or from sand which has been dried.

Green Vitriol (*Chem.*) A common name for ordinary crystallised ferrous sulphate, $FeSO_4 7H_2O$. *See* IRON COMPOUNDS.

—— (*Min.*) A synonym for MELANTERITE or COPPERAS (*q.v.*)

Green Wood. Timber still containing some of its original sap, which must be removed by seasoning before the timber is fit for use.

Gregorian Calendar (*Astron.*) The calendar as adopted by employing the corrections ordered by Pope Gregory in 1582.

Gregorian Modes (*Music*). *See* MODES.

Gregorian Telescope (*Astron.*) A form of reflecting telescope in which the observer views the object by looking through an aperture in the primary mirror at the image formed by a small concave reflector in the primary axis.

Grenadine (*Textile Manufacture*). An open texture in stripes or checks, several threads being compacted together in the warp, in the weft, or in both, and open spaces intervening.

Grey (*Paint.*) A colour intermediate between black and white. A mixture of black and white.

—— (*Textile Manufac.*) A term used to describe yarn or "slubbing" as it comes from the loom before undergoing any process of bleaching or dyeing.

Grey Copper (*Min.*) A synonym for TETRAHEDRITE (*q.v.*)

Grey Lime (*Build.*) A lime prepared from grey chalk.

Grey Pig (*Met.*) Pig iron which gives a flaky crystalline fracture which is dark grey, due to graphitic carbon (*q.v.*) For foundry use it is a hard iron giving a fluid metal in the ladle. White pig is a definite carbide of iron, the carbon being combined. Is more sluggish than grey, and usually contains more sulphur. Mottled pig is intermediate between grey and white pig. *See also* IRON.

Grey Sour (*Cotton*). Dilute hydrochloric (muriatic) acid, used to decompose the lime soaps formed in the lime-boiling kier in cotton bleaching.

Greywacké (*Geol.*) An Anglicised form of the German name Grauwacké, which is now applied by British geologists to an impure form of quartzite which constitutes a large part of the Silurian, Ordovician, Cambrian and pre-Cambrian rocks of marine

sedimentary origin. The Coniston Grits of the English Lake District consist almost entirely of typical greywacké.

Grid (*Eng.*) A general term for structures composed of parallel bars, *e.g.* a grating over the opening of a pipe, etc.

Griddle (*Mining*). A sieve or grating.

Gridiron Pendulum. *See* PENDULUMS.

Gridiron Valve. A slide valve containing parallel rectangular openings or ports; the solid portions between the ports cover corresponding openings or ports in the valve seat, so that a small movement of the valve will uncover a large port area by bringing the two sets of openings opposite each other.

Griffe (*Architect*). A projecting spur at the base of a column; found chiefly in mediæval architecture.

—— (*Textile Manufac.*) The frame containing the lifting bars in the harness or Jacquard loom.

Griffin *or* **Gryfin,** *anciently* **Gryphon** (*Her.*) A fabulous beast with eagle's head and claws joined to a lion's body. When borne as a charge it is generally "passant," but when erect and wings expanded it is called "segreant." Griffins are frequently borne as supporters.

Griffith's White (*Dec., etc.*) A white pigment similar in composition to Orr's Zinc White (*q.v.*)

Grille (*Build., etc.*) (1) A grating. (2) A screen made in the form of a grating.

Grinder (*Paper Manufac.*) A machine used for making mechanical wood pulp (*q.v.*)

Grinding. (1) The process of crushing a material into powder or small particles. (2) The removal of material from an object by the action of some abrading substance; *e.g.* an emery wheel, grindstone, etc.

—— (*Textile Manufac.*) An operation performed periodically by means of emery rollers on the wire edged surfaces of the cylinder, doffers, flats, etc., of a carding engine, so as to ensure accurate carding. The particular method of grinding is determined in a large measure by the staple to be carded. There are several forms of grinding, such as PLOUGH GRINDING, TOP GRINDING, SIDE GRINDING, etc.

Grinding In (*Eng., etc.*) Fitting a plug or valve to its seat by placing a little fine emery on the valve and rotating it in its seat until a good fit is secured. The valves of gas engines, petrol motors, etc., require to be ground in at intervals when they become loose through corrosion caused by the hot gases in the cylinder.

Grinding Rest (*Eng., Carp., etc.*) A device used to support a tool which is being ground, so that the edge is sharpened to the correct angle.

Grinding Stone (*Eng., etc.*) (1) A flat stone used for grinding pigments. (2) A circular stone mounted on a frame, and used for grinding tools; usually termed a GRINDSTONE.

Grindstone. A circular rotating disc of some natural sandstone (*e.g.* the carboniferous sandstone from Newcastle), more rarely made of some artificial composition; generally used for sharpening cutting tools and implements.

Grisaille (*Paint.*) A method of painting in monotone, grey tints only being employed. Generally used for representing solid bodies in relief, *e.g.* friezes, bas-reliefs.

Grits (*Geol.*) A term applied somewhat loosely to any rough textured sandstones. It is very generally used for the pebbly sandstones of the Carboniferous Rocks, and especially for those whose texture fits them for use as millstones.

Grizzle (*Build.*) A stock brick, underburnt, but of good shape.

Groin (*Architect*). *See* GROINED VAULT.

Groined Vault (*Architect.*) A groined vault is formed by the intersection of two barrel vaults, the angles formed at the intersection being known as GROINS. The groins divide the vault over a rectangular space into four parts, hence the terms quadripartite and four-part vault. A groined vault must be constructed as one structure, wooden centring being used to support the whole. This form of vault was used by the Romans and also in the Romanesque style. *See* BARREL VAULT, VAULT, *and* RIB AND PANEL VAULT.

Grolier (*Binding*). A style of book ornamentation introduced into France in the time of Henri Deux by his Chancellor, Grolier, who is supposed to have learned it in Italy. It consists of interlaced strap work of different colours, applied to book sides. It bears great similarity to some kinds of early Celtic decoration.

Grooving. (1) A general term for cutting a groove. (2) The production of the groove in the edge of a board which is to be joined to another board provided with a TONGUE or strip fitting the groove; it is done either by hand with the PLOUGH (*q.v.*) or by a revolving saw or cutter of suitable thickness.

Grooving (*Eng.*) The tendency of corrosion in steam boilers to develop cracks into grooves. It occurs chiefly along the edges of laps, angle bars, and doubling plates, owing to the shell being too stiff to allow the boiler to "breathe," *i.e.* expand and contract evenly. Cylindrical shells, if too firmly seated, suffer from grooving, owing to the plates buckling near lap and butt straps, especially at ring seams. But in vertical fireboxes want of stiffness causes grooving through the mud ring not being deep enough. Grooves often owe their origin to the use of caulking tools which are square or sharp, instead of being perfectly round nosed.

Grooving Saw (*Carp., etc.*) A revolving saw used for cutting a groove in timber for a tongue and grooved joint. It may either be a drunken saw (*q.v.*) or a saw of thickness equal to the required groove running truly on its spindle.

Gros (*Silk Manufac.*) A coarse form of tabby, the bolder effect of cord being obtained by two or more picks passing into the same shed.

Grossularite (*Min.*) A calcium aluminium garnet (*see* GARNET), greenish or yellow, translucent. Composition approximately, $Si = 40$, $Al_2O_3 = 15$, $Fe_2O_3 = 10$, $CaO = 33$ per cent, with a trace of magnesium. From Siberia and Norway.

Grotesques (*Art*). Pictures or systems of ornament representing fantastic subjects. Arabesques consisting of extravagant figures fancifully combined with foliage, etc.

Ground (*Mining*). The rocks round a lode, often termed COUNTRY ROCK or merely COUNTRY.

—— (*The Arts*). (1) A foundation, used either for support or display. (2) A surface, natural or pre-

pared, which serves as a basis, especially in decorative art. (3) The principal colour employed on a picture. *See also* MEZZOTINT *and* ETCHING (*under* ENGRAVING).

Ground Air. It is found that all soils contain air, the quantity varying with the porosity and nature of the strata. Thus, loose sands contain as much as 50 per cent., while the densest rocks are free from it. It is especially rich in carbon dioxide, derived from the oxidation of the organic matter, the amount of which increases with the depth. The oxygen decreases in quantity with the depth. Nitrogen is present in nearly the same proportion as in the atmosphere. Occasionally the ground air contains ammonia, various hydrocarbons, and nitric acid. Ground air is in continual movement, the causes being: (*a*) the diurnal changes of temperature, (*b*) rainfall, (*c*) variations in barometric pressure, (*d*) fluctuation of ground water. To ascertain the amount of ground air present in a soil, a burette is taken and filled with the soil. Water is allowed to pass through the burette until it reaches the surface, thus expelling all the air, then

$$\frac{\text{the amount of water}}{\text{the amount of dry soil}} \times 100$$

gives the percentage of air.

Ground Bass (*Music*). A musical phrase constantly repeated in the bass with varied harmonic devices at each repetition above.

Ground Glass. Glass whose surface has been ground or roughened by rubbing with fine sand or emery, etc. It serves as a semi-transparent screen in photography and in various optical devices.

Groundlayer (*Pot.*) Groundlaying is the process of laying an even coat of colour over the surface of pottery or porcelain. The glazed ware is first coated with an oil which is dabbed carefully to render the surface perfectly even. The colour, in the form of a fine powder, is then dusted over the oil, to which it adheres; it is then burnt in the requisite kiln.

Ground Mass (*Geol.*) The non-crystalline lithoidal or vitreous material of any eruptive rock in which the crystalline portions are embedded.

Ground Nut (*Botany*). A small West African plant, *Arachis hypogea* (order, *Leguminosæ*), of the pea family, whose seeds yield a valuable oil used as a substitute for olive oil, and (on the Continent) in soap making. The nut is known in England as MONKEY NUT, and in America as PEA NUT. In the latter country it is used extensively as food, being usually sold freshly roasted. The name Ground Nut is applied to it from the fact that the nuts or seeds grow underground.

Ground Water. If a hole is dug in any soil a point is reached at which the interstices are found full of water. This point denotes the level of the ground water. This varies considerably in different localities. In some instances it is only a few feet from the ground level, while in other cases it is many hundreds of feet. As with ground air, ground water is in continual movement. It also fluctuates in level, being largely influenced by rains.

Grouting (*Build.*) Filling up joints, holes with ironwork sunk into them, etc., with thin fluid mortar, which can be poured into the cavities.

Grove Cell (*Elect.*) *See* CELLS, PRIMARY.

Groynes (*Civil Eng.*) Barriers of masonry (or more often of wood) running out at right angles to the coast line to protect the beach from erosion by the waves.

Grummet *or* **Gromet.** Twisted rope or yarn, used for packing joints in iron work which have to be made watertight.

Guaiacol (*Chem.*) $C_6H_4 \langle {OH \atop OCH_3}$. Colourless prisms; melts at 28° C.; smells like creosote. Its alcoholic solution gives a green colour with ferric chloride. It occurs among the products of dry distillation of GUAIACUM RESIN, and in beech creosote. It can be prepared from pyrocatechin (*q.v.*) by heating with caustic potash and potassium methyl sulphate. Is used as a medicine in phthisis, as it is believed to aid in the destruction of the bacilli in the lungs.

Guaiacum (*Botany*). This resin, used in pharmacy, is obtained from the stem of *Guaiacum officinale* (order, *Zygophyllaceæ*) by incision or exudation. The heartwood is also used in medicine.

Guanidine (*Chem.*) $HN:C \langle {NH_2 \atop NH_2}$. A colourless crystalline solid, very soluble in water and alcohol; a powerful monacid base. It may be prepared by heating together cyanamide and ammonium chloride with alcohol at 100°, usually by heating ammonium sulphocyanate for twenty hours at 180° to 185° C., when a residue of guanidine thiocyanate remains, from which the base can be obtained by conversion into sulphate by sulphuric acid and precipitation with baryta water. Guanidine heated with dilute sulphuric acid yields urea and ammonia: baryta water decomposes it in a similar way. On treatment of its salts with sulphuric and nitric acids, NITRO-GUANIDINE, $HN \langle {NHNO_2 \atop NH_2}$, a white crystalline solid, is formed, which on reduction with zinc dust and acetic acid gives AMIDO-GUANIDINE (*see* HYDRAZINE), which yields DIAZO-GUANIDINE, nitrate with nitric acid and sodium nitrite. The diazo-compound yields azoimide (*q.v.*) on boiling with alkalis.

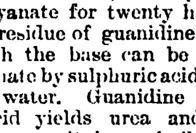
$$HN = C \langle {NH - N = N - NO_2 \atop NH_2}$$

$$= CN.NH_2 + {N \atop \| \atop N} \rangle NH + HNO_3.$$

An important decomposition product of albumins is ARGININE, which is guanidine aminovalerianic acid,

$$HN = C \langle {NH_2 \atop NHCH_2CH_2CH_2.CHNH_2.COOH.}$$

Creatine and creatinine (*q.v.*) are also guanidine derivatives.

Guanine (*Chem.*) 

(2-amido-6-oxypurine). A white amorphous powder which can be crystallised from an ammoniacal solution; insoluble in water and in alcohol. Occurs widely distributed in animal tissues; fish scales contain the crystallised calcium compound of guanine, and are used under the name of PEARL ESSENCE in making artificial pearls; guano contains considerable quantities of it, and serves as the chief source; it is also a decomposition product of nuclein (*q.v.*) It has been obtained synthetically by heating 6-oxy-2:8-dichlorpurine with alcoholic ammonia and re-

duction of the chlorguanine thus produced by hydriodic acid. *See* PURINE. Treated with nitrous acid it yields XANTHINE (*q.v.*); on oxidation with hydrochloric acid and potassium chlorate it yields guanidine and parabanic acid (*q.v.*); unites with both acids and bases to form salts.

Guano. The dung of sea birds, found in large deposits upon the coast of South America. The Chincha islands are the principal sources of the Peruvian guano. It forms a valuable manure.

Guard Plate (*Eng.*) A dish shaped piece of metal fixed over the rubber disc of an indiarubber valve, convex side downward, so as to regulate the height to which the valve disc can rise.

—— (*Met.*) The perforated plate at the top of the tuyere box through which the blast passes into the bottom of a Bessemer converter.

Guard Rail (*Eng.*) A short rail laid parallel to an ordinary (railway) rail to guide the wheels of the vehicles where points and crossings occur; the guard rail comes into contact with the flanges of the wheels if the latter tend to leave the rails.

Guard Ring (*Elect.*) A wide ring of metal surrounding a flat plate, so as to form a surface practically continuous with the plate; used in the Attracted Disc Electrometer to ensure a uniform distribution of electricity over the surface of the disc.

Guards (*Bind.*) Narrow strips of paper inserted between the leaves at their backs, *e.g.* in albums, scrapbooks, etc., so that when the book is filled with photographs, or the pieces pasted on the leaves, the fore-edge shall not be thicker than the back. Guards, consisting of narrow strips of linen, are also employed for firmly securing plates in books, the plate being attached to the guard by means of some adhesive substance.

Gudgeon (*Eng.*) The shaft at right angles to a piston rod, to the ends of which the SLIPPER BLOCKS (*q.v.*) are attached.

Gudgeon Pin (*Eng.*) A connecting pin such as that which connects the connecting rod to the piston in gas or petrol engines. It serves as the axis about which the rod swings as it follows the motion of the crank.

Guide (*Eng.*) Any device by which an object is caused to follow a definite path; it is a term of very wide application.

Guide Bars (*Eng.*) The straight bars which cause the SLIDE BLOCKS or SLIPPER BLOCKS (*q.v.*) of an engine to move in a straight line, and so prevent the connecting rod from straining the piston rod, in consequence of its obliquity, as it follows the motion of the crank. *See* STEAM ENGINE.

Guide Pulley (*Eng.*) A loose pulley (*i.e.* one which revolves freely on its own axle or shaft), used to guide or steady a driving belt, etc.

Guide Screw (*Eng.*) The LEADING SCREW (*q.v.*) of a screw cutting lathe.

Guignet's Green (*Dec.*) One of the most permanent greens known. It is made by heating boracic acid and bichromate of potash, and is usually known as CHROME GREEN. A mixture of Prussian blue and chrome yellow is often sold for this pigment.

Guilloche (*Architect.*) An ornament used on the torus in classical architecture, and consisting of two or more interlacing bands.

Guillotine (*Bind. and Paper Trades*). A machine for cutting book edges, paper, etc., by action of a descending knife on the compressed material. It is named after the celebrated instrument of French capital punishment, and has almost superseded the plough and cutting press in bookbinding.

Guinea Corn (*Botany*). *See* DHURRA.

Guitar. *See* MUSICAL INSTRUMENTS—STRING (BY HAND).

Gules (*Her.*) The colour or tincture red; abbreviated to "gu"; expressed in engravings by perpendicular lines. *See* HERALDRY.

Gulf Stream (*Meteorol.*) The warm current flowing across the North Atlantic from S.W. to N.E. It produces considerable effect on the climate of north-west Europe, which would otherwise be much colder during the winter months.

Gullet. *See* SAW GULLET.

Gulleting (*Carp., etc.*) Filing out and deepening the hollow between the teeth of a circular saw. *See also* SAW GULLET.

Gully (*Build.*) A trap or cesspool into which waste and rain water pipes discharge.

Gum. *See* WOODS.

—— (*Chem.*) Gums are amorphous, transparent carbohydrates, which form a mucilage with water; insoluble in alcohol; heated with dilute acids they yield sugars, and oxidised by nitric acid they yield oxalic or mucic acids.

Gum Animé. A valuable copal gum principally received from Zanzibar. Its sp. gr. is 1·068, and the melting point 450°F. It sells on the London market from two hundred to three hundred and fifty pounds per ton.

Gum Arabic *or* **Gum Acacia.** The gum is an exudation from the stem and branches of *Acacia Senegal* (order, *Leguminosæ*) during the dry season. It forms rounded masses or "tears" of a yellowish colour, often transparent. Its principal constituent is ARABIC ACID or ARABIN $(C_6H_{10}O_5)_2 + H_2O$, a white amorphous solid. Boiled with dilute sulphuric acid, gum arabic yields much galactose (*q.v.*) It is used in medicine.

Gum Benzoin. *See* BALSAMS.

Gum, Black. *See* WOODS.

——, **Blue.** *See* WOODS.

——, **British.** *See* DEXTRINE.

Gum Copal. A generic term applied to a large class of gum resins, including hard copals from India and the east coasts of Africa. Copals are much used in varnish making, and possess the property of not dissolving unless previously fused.

Gum Dammar *or* **Damar** (*Dec.*) A soft gum used in varnish making. There are several varieties, one being white, the others nearly black. The gum is too soft to make oil varnishes, but is frequently mixed with turpentine in about equal proportions for special varnishes.

Gum Elemi. A balsam used in varnish making. It possesses a peculiar property of softness, and may be cut by a knife. It melts at 80° F., is partially fluid at 100°, and wholly so at 200°.

Gum, Kauri. A semi-fossil gum, much used in recent years in varnish making, particularly for oak varnish. It exudes from a pine tree found in New

Zealand (*Dammara Australis*). It unites with linseed oil quicker and at a lower temperature than any other resin. The melting point is 380° F. to 460° F., and the sp. gr. 1·070 to 1·080.

Gum Mastic. This gum oozes in the shape of tears from cuts made in trees. It is used for making the colourless varnishes employed by artists to preserve oil paintings, and possesses the advantage that it may be removed with facility when discoloured by age or dirt, as the resin is readily soluble in alcohol or turpentine.

Gumming of Oils (*Dec., etc.*) A condition of "drying" oils (such as linseed oil) which have been exposed to the air and have become thick or gummy by absorption of oxygen. In this condition they are not fit for painter's use in the ordinary way; but gummed oils are sometimes added to refuse paint which is thinned and reground.

Gum Pot. A vessel in which gum is melted in the manufacture of varnish (*q.v.*)

Gum, Red. *See* WOODS.

——, Sandarac. A resin which exudes from the *Callitris quadrivalvis*. It is hard but brittle, smells slightly of turpentine, and melts at 135° F. Used for special varnishes in combination with other gums.

——, Sweet. *See* WOODS.

——, Tasmania. *See* WOODS.

Gum Thus. The best quality of crude turpentine (*q.v.*)

Gum Tragacanth. Derived from various species of *Astragalus*, and is used largely in calico printing. It also forms an ingredient of various agglutinants, such as a paste for sticking labels on a smooth surface.

Guncotton *or* **Pyroxylin** (*Chem.*) $C_{12}H_{14}(NO_3)_6O_4$; also called CELLULOSE HEXANITRATE or NITRO-CELLULOSE. A solid not unlike cotton in appearance; insoluble in water, alcohol, ether; soluble in ethyl acetate. It is prepared by the action of a mixture of nitric acid and sulphuric acid on pure cotton; the time of immersion is short, and the product must be exceedingly well washed with water. The product is a true nitrate and not a nitro compound, because alcoholic potassium hydrosulphide gives cotton and potassium nitrate when digested with guncotton. It burns readily and so quickly that it may be ignited safely on the palm of the hand. When struck by a hammer on an anvil, the part struck alone detonates. Compressed guncotton is detonated by mercury fulminate (*q.v.*), and this is the way it is detonated in practice. In air it is burnt completely to carbon dioxide, water, and nitrogen; when fired in closed vessels, as it does not contain sufficient oxygen for its own combustion, carbon monoxide and hydrogen are also produced. The gases produced on firing measure (at 0° and 760 mm.) about 700 times the volume of the guncotton, and the temperature generated is exceedingly high—probably over 3000° C.

Gun Metal (*Eng.*) An alloy of copper and tin (often 9 copper to 1 tin). Used for bearings, small castings requiring a good finish, parts of electrical machinery which must be non-magnetic, etc.

Gunpowder. An intimate mixture of potassium nitrate, sulphur, and charcoal. The nitrate and sulphur are especially purified, and the charcoal is made from a soft wood, dogwood (*Cornus*). The proportions vary slightly but may be taken as very nearly 75 parts of nitrate, 15 of charcoal, and 10 of sulphur. The materials are mixed in a moist state, pressed into a cake, and granulated in a special machine, and then polished—the small grain powder, by simple friction of the grains against each other, the large grain by addition of graphite (black lead). Gunpowder explodes about 300° C.; the rate of explosion depends on the pressure under which it is fired; under very low pressures it will not explode at all. The principal gaseous products of its explosion are carbon dioxide, nitrogen, carbon monoxide, hydrogen, sulphuretted hydrogen, and marsh gas. The hydrogen is furnished by the moisture in the powder and gases occluded in the charcoal used in its manufacture. The principal solids are potassium carbonate, sulphate, sulphides, and sulphocyanate. The volume of gas produced is about 300 times that of the powder, the gases being measured at 0° and 760 mm.; the temperature is estimated at about 2000° C., and the pressure produced varies with the ratio of the volume of powder to the capacity of the containing space. When this ratio is 1, the pressure is about 42 tons to the square inch.

Gurgoyle (*Architect.*) *See* GARGOYLE.

Gurjun Balsam. A resinous exudation from the base of the stem of *Dipterocarpus lævis* (order, *Dipterocarpaceæ*). It is used as a varnish under the name of WOOD OIL. The tree is a native of the East Indies.

Gusset (*Arm.*) Portions of chain mail used in plate armour at the joints, *e.g.* armpits and ankles, to allow of greater freedom than a plain hinge could afford.

—— (*Eng.*) A bracket or stay used to strengthen the joint between two surfaces which meet at an angle, the gusset being in a plane at right angles to both.

—— (*Her.*) An abatement of honour; portions cut out from the side of a shield. An ancient charge fallen into disuse.

Gusset Plate (*Eng.*) A much used form of end stay for boiler plates and heads, being corner plate stays as opposed to stirrup and rod stays. They should always be joined by double angles with rivets in double shear, not less than 4 in. apart. In reason, the greater the distance apart the better, in order to afford "play or breathing" and avoid grooving (*q.v.*)

Gut Bands (*Eng., etc.*) Driving belts of catgut are used with small and fast running machines, for belt driven motor cycles, etc.

Guttæ (*Architect.*) Small droplike ornaments formed on the soffit of the mutules and under the triglyphs in the Doric entablature. The guttæ in the Greek Doric entablature are much shorter than those used by the Romans. *See* CAPITAL OF GUTTÆ *and* ARCHITECTURE, ORDERS OF.

Gutta Percha. The saplike gum collected from various trees (*Sapotaceæ*) growing in the Indian Archipelago, but chiefly from *Dichopsis gutta*. It differs from rubber (caoutchouc) in being plastic, but not elastic; nor can it be vulcanised. It is collected from trees felled immediately after the rainy season. Owing to the fact that it is not affected by caustic alkalis or by dilute acids, gutta percha is used in the manufacture of syphons, funnels, and other chemical apparatus, while its acoustic properties render it suitable for stethoscopic and other aural instruments. It is also used to form driving bands for small

machinery, and extensively as an insulator in telegraphy. It is also the medium now used for making the blocks in electrotyping.

Guttée *or* **Gouttes** (*Her.*) From the Latin *gutta*, a drop. A field may be covered with gouttes. They are of several tinctures, *viz.* Guttée d'or, de larmes or d'eau, du sang, de vert or d'olive, and de poix.

Gutter (*Build.*) A channel to carry off the rain from a roof.

—— (*Print. and Bind.*) Another term for the "back" or inner margin of the printed page of a volume.

Gutter Bearers (*Build.*) The pieces that support the gutter boards.

Guttiferæ (*Botany*). A tropical Dicotyledon order whose timbers, resins, and fruits are of value.

Guy Rope. A rope that keeps a derrick vertical.

Guze (*Her.*) A roundlet of "murry" or "sanguine," blood colour; a charge now seldom used.

Gymnospermæ (*Botany*). A great division of the seed plants, differing from the flowering plants in the characters of the carpels and ovules. The Conifers are the best known members of the division.

Gynæceum (*Botany*). The term applied to the carpels of a flower.

Gypsum (*Min.*) Hydrous sulphate of calcium, $CaSO_4 . 2H_2O$. Lime = 32·6, sulphuric acid = 46·5, water = 20·9 per cent. Crystallises in the monosymmetric system (SELENITE). More often massive and granular in beds, or fibrous in veins. Can be scratched by the nail. Colourless to brown. It is used to some extent to harden the water in brewing, but chiefly to make plaster of Paris; for this purpose it is heated, to drive off water, and then ground. On the addition of water, hydration takes place and it sets. From many parts of England, and largely from Montmartre near Paris.

Gyration, Centre of. *See* PENDULUM.

Gyronny (*Her.*) A field divided into several parts of gyrons. A gyron is one of the ordinary divisions of a shield.

H (*Elect.*) (1) A general symbol for the MAGNETISING FORCE (*q.v.*) at a point; especially (2) the HORIZONTAL INTENSITY of the Earth's Magnetic Field. *See* HORIZONTAL FORCE.

—— (*Music*). The German name for B♮. Their B is our B♭.

Hacking (*Plast.*) Roughening the surface of a brick wall with a hammer to form a KEY (*q.v.*) for the plaster.

Hacking Hammer (*Plast.*) A plasterer's hammer, used for cutting away old plaster, etc.

Hackling (*Linen Manufac.*) The rough flax as it comes from the scutch mills requires to be combed to free it of all short and twisted fibres, and to split up all parcels of fibres that may be sticking together. The first hackling is called ROUGHING, then finer combs are used, or MACHINE HACKLES may take the place of finer hand hackles. After hackling, the flax is a nice straight silky fibre. *See* LINEN MANUFACTURE.

Hack Off (*Plast.*) To cut away old plaster with a hammer.

Hack Saw (*Eng.*) A narrow saw of hard steel stretched on a frame; used for cutting metals.

Haddock. A food fish of the cod tribe, *Gadus æglefinus* (family, *Gadidæ*), attaining a large size in northern seas, and eaten in a fresh or smoked condition.

Hade (*Geol.*) Originally a miners' term for the inclination measured from the vertical of the plane of a FAULT (*q.v.*) This varies very much in different cases, and may be different in various parts of the same fault if the rocks through which the fault passes happen to show a wide range in petrographical characters.

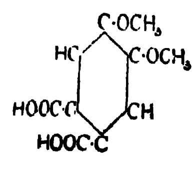
Hæmateïn (*Chem.*), $C_{16}H_{12}O_6$. Lustrous dark green solid, or, when powdered, a lustrous reddish brown powder; sparingly soluble in water and alcohol. It dissolves in ammonia with a purple colour. To obtain it, hæmatoxylin (*q.v.*) is cautiously oxidised by nitric acid. It is to the formation of this substance from the hæmatoxylin of logwood that the dyeing powers of the latter are due. With chromium and iron mordants it dyes black on silk, wool, and cotton.

Hæmatin (*Chem.*) *See* HÆMOGLOBIN.

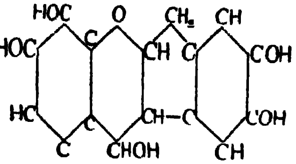
Hæmatite (*Min.*) Ferric oxide, Fe_2O_3. Iron = 70, oxygen = 30 per cent. Also called SPECULAR IRON. Rhombohedral. Crystals steel blue to black, blood red if very thin; massive varieties are blood red; both have a characteristic blood red streak. It is an important ore of iron, occurring in irregular replacement deposits in limestone or in calcite veins underlying rocks containing hæmatite in a disseminated state. The variety KIDNEY ORE is so called from the reniform shape of the masses. REDDLE is an earthy variety. SPECULAR IRON is so called from the mirrorlike surfaces of the crystals. Besides being used as an ore, this mineral is used in polishing and burnishing, both in the mass and when powdered. It occurs in large quantity in West Cumberland and North Lancashire, but much of the so-called hæmatite of this district is really a ferric hydrate related to Turgite (*q.v.*) Also in the south-west of England, in Elba, and in Missouri, U.S.A.

Hæmatoporphyrin (*Chem.*) *See* HÆMOGLOBIN.

Hæmatoxylin (*Chem.*), $C_{16}H_{14}O_6$. A colourless crystalline solid which becomes red on exposure to light; sparingly soluble in cold water, readily in hot water, in alcohol, and ether; it has a sweet taste; it is dextrorotatory. The *acid* solution is yellow; the alkaline solution is purple; the neutral solution is colourless. It is extracted from logwood by aqueous ether. On gentle oxidation it yields HÆMATEÏN (*q.v.*), and on this property the dyeing properties of logwood are based. In fusion with potash it yields RESORCIN (*q.v.*) and pyrogallic acid; it forms a penta-acetyl derivation. On oxidation of its tetramethyl derivative it yields, among other products, metahemipinic acid—



On these and other grounds Perkin proposes the formula



Hæmatoxylon (*Botany*). *H. campechianum*, a leguminous tree of tropical America, yields the logwood of commerce.

Hæmin (*Chem.*) *See* HÆMOGLOBIN.

Hæmochromogen (*Chem.*) *See* HÆMOGLOBIN.

Hæmocyanin (*Chem.*) A substance found in the blood of certain molluscs and crustacea. Like hæmoglobin it absorbs oxygen, but is turned to a beautiful blue colour by it; this is due to the fact that it contains copper instead of iron, which is contained in hæmoglobin. It is a proteid.

Hæmoglobin. The red colouring matter of the blood of vertebrates; it is the principal constituent of the red corpuscles. It may be obtained by adding salt to blood and separating the corpuscles by a centrifugal machine, then treating the corpuscles with a little ether. On allowing the ether to evaporate the hæmoglobin crystallises out. Hæmoglobin preparations from the blood of different animals show differences in solubility, in crystalline form, and in ease of crystallisation: that from most animals crystallises in prisms, but that of the guinea pig in octahedra. The hæmoglobin of rat or dog blood crystallises more readily than that from human blood. Chemically, hæmoglobin appears to be the same substance, whatever its source. Hæmoglobin contains carbon, hydrogen, nitrogen, oxygen, iron, and sulphur. It combines (molecule for molecule) with oxygen, carbon monoxide, and nitric oxide. In the blood it exists as hæmoglobin (sometimes called reduced hæmoglobin), and combines with oxygen to form oxyhæmoglobin. From its content in iron and its union with carbon monoxide a minimum molecular weight of 16,669 has been calculated for hæmoglobin, and from this value for its molecular weight and the percentage of its constituent elements the formula $C_{758}H_{1203}N_{195}O_{218}FeS_3$ has been calculated for it. As these results were obtained with pure recrystallised material, they are probably near the truth. It gives the same precipitation and colour reactions as the albumins (*q.v.*) Hæmoglobin is the oxygen carrier of the blood; in the lungs it is changed to oxyhæmoglobin, and the bright red colour of arterial blood is due to this compound. The oxyhæmoglobin gives up its oxygen to the tissues, and is reduced to hæmoglobin, the dark red colour of venous blood being due chiefly to hæmoglobin, but not entirely, as venous blood contains some oxyhæmoglobin. This absorption and giving up of oxygen can be imitated artificially. A bright red solution of oxyhæmoglobin gives up its oxygen under the receiver of an air pump, and changes to a dark red solution of hæmoglobin, or the same change can be brought about by passing a stream of an indifferent gas, such as nitrogen or hydrogen, through the oxyhæmoglobin solution; then, on exposing the hæmoglobin to air, or passing oxygen through it, the oxyhæmoglobin is reproduced. The compound of hæmoglobin with carbon monoxide (carboxyhæmoglobin) is produced when carbon monoxide is passed through a hæmoglobin solution. It has a cherry red colour, and is far more stable than oxyhæmoglobin, and is formed in the blood when air containing carbon monoxide is inhaled. Should half the hæmoglobin of the blood be transformed to carboxyhæmoglobin, death results; but when less than this amount is transformed, oxygen can still decompose the carboxy compound, and recovery follows. Hæmoglobin can combine with oxygen in a much more stable way than when it forms oxyhæmoglobin. This stable oxygen compound is called methæmoglobin, and it is formed when oxyhæmoglobin is allowed to stand; also by a large number of substances, some of which are oxidising agents (*e.g.* potassium chlorate and nitrate) and reducing agents (*e.g.* hydrogen and pyrogallic acid). Potassium ferricyanide—an oxidising agent—is generally used to produce methæmoglobin. It does not give up oxygen under reduced pressure, like oxyhæmoglobin. Ammonium sulphide and Stokes's reagent (a solution of ferrous sulphate and tartaric acid to which ammonia has been added) transform methæmoglobin first to oxyhæmoglobin, then to hæmoglobin. Hæmoglobin and all its derivatives mentioned above show characteristic absorption spectra. The carboxyhæmoglobin spectrum is used as a test for carbon monoxide in air, and though it rather resembles the oxyhæmoglobin spectrum, it is sharply distinguished from the latter by remaining unchanged on addition of ammonium sulphide to the solution under examination, while the oxyhæmoglobin spectrum changes to that of hæmoglobin. Hæmoglobin on treatment with dilute acid is resolved into an albumin globin and a substance hæmatin, which contains all the iron of the hæmoglobin. Hæmatin is obtained in the form of its crystallised hydrochloride, called hæmin (Teichmann's blood crystals), by treating coagulated blood corpuscles with amyl alcohol and hydrochloric acid. The formation of these crystals constitutes the most reliable test for a stain supposed to be due to blood. On treatment with caustic soda and precipitation with hydrochloric acid, hæmin yields hæmatin as a blue black amorphous solid, which is easily soluble in alkalis and in acidified alcohol. Its solutions show different absorption spectra according as they are alkaline or acid, the acid spectrum resembling that of methæmoglobin. Like hæmoglobin, hæmatin can combine with oxygen; in fact, the oxygen compound is generally called hæmatin, while the oxygen free compound is called reduced hæmatin or hæmochromogen. When hæmatin hydrochloride (hæmin) is treated with an acetic acid solution of hydrogen bromide, and the solution gently warmed, a compound called hæmatoporphyrin is formed. This substance has the formula $C_{34}H_{38}O_6N_4$: the hæmatin has given up iron. From both hæmatoporphyrin and hæmatin there is obtained by oxidation the anhydride of the tribasic hæmatinic acid, which is identical with methyl-β-carboxyethyl maleic acid anhydride:

$$\begin{array}{rl} CH_3.C & -\ CO \\ \Vert & \quad > O \\ COOH.CH_2CH_2\ C & -\ CO \end{array}$$

From hæmatin by reduction with hydriodic acid and phosphonium iodide there arises first mesoporphyrin, $C_{34}H_{38}O_4N_4$, and then hæmopyrrol, which is ββ'-methylpropylpyrrol, and yields on oxidation methylpropyl malcic acid imide:

$$\begin{array}{rl} CH_3.C & = CH \\ \vert & \quad > NH \\ CH_3.CH_2.CH_2.C & = CH \end{array} \longrightarrow \begin{array}{rl} CH_3.C & - CO \\ \Vert & \quad > NH \\ CH_3.CH_2.CH_2.C & - CO \end{array}$$

See PHYLLOPORPHYRIN.

Hagioscope (*Architect.*) An oblique opening frequently found on one or both sides of the chancel arch in a church to enable persons in the aisles and transepts to see the performance of certain ceremonies at the altar. These openings are also known as SQUINTS.

Ha-ha (*Architect., etc.*) A boundary fence sunk in a hollow.

Hail (*Meteorol.*) Ice crystals forming masses very much denser than snow. They are caused by rain drops becoming frozen in their passage through the air. Sections of them show that they pass through several distinct cold air strata.

Hailstones (*Meteorol.*) Are generally of a conical or round form, and when cut across are composed of layers of clear and opaque ice with a snowy nucleus. They vary in size from a small shot to several inches in diameter. *See* HAIL.

Hair Compass (*Eng.*) A small pair of spring compasses with a fine adjustment actuated by a set screw.

Hairline (*Textile Manufac.*) A fine STRIPE made in woollen and worsted YARNS. A standard fabric in the west of England.

Hairline Letter (*Typog.*) A very thin-faced type, often used for lettering mounts.

Hair Pencil (*Paint.*) A painter's brush; the hairs are generally mounted in a quill for watercolours, and in a metal tube for oils.

Hair Side (*Leather*). The side of a skin on which the hair grew, *i.e.* the outer side.

Hair Space (*Typog.*) The thinnest space used by printers, often used for spacing headlines of books.

Hair Spring (*Watches*). *See* BALANCE SPRING.

Hake (*Zoology*). A food fish of the cod tribe, *Merluccius vulgaris* (family, *Gadidæ*), found largely on the coast of Cornwall. The flesh is eaten fresh or salted.

Halation (*Photo.*) A blurring of the image; an encroachment of the high lights on the darker portions next to them; caused by reflection from the back of the plate. In order to prevent this, some material is applied "in optical contact with the glass" which will absorb those rays that act chemically upon the sensitive surface. The substance which answers best is probably asphaltum.

Halberd *or* **Halbert** (*Arms*). A weapon used during the fifteenth and sixteenth centuries. It consisted of an axe with a spike or spearhead at one end, the other end being attached to a handle or staff about 6 ft. long and in line with the spike. Subsequently it was used by bodyguards for display.

Halecret, Allecret (*Cost.*) Light plate armour forming two corslets, lighter than a cuirass, and worn alike by horsemen and footmen in the sixteenth century.

Half Bound (*Binding*). Books with leather backs and corners and cloth or marbled paper sides, as distinguished from books wholly covered in leather.

Half Case (*Typog.*) A small case used for jobbing work.

Half Centre (*Eng.*) The position of an engine crank when at right angles to the line of the piston rod.

Half Close (*Music*). Another term for imperfect cadence. *See* CADENCE.

Half Lap Coupling (*Eng.*) Two shafts connected by a half lap joint (*q.v.*)

Half Lap Joint (*Eng., Carp., etc.*) A joint in two pieces of material which are in the same straight line with each other, the joint being formed by cutting away a portion of the material in each of the parts to be joined; the portion removed is equal to half the thickness of each of the members. Also termed HALVING.

Half Length (*Art*). A portrait representing only the upper half of a person.

Half Period Zones (*Light*). In order to deal with the problem of illumination at a given point due to a light wave from a luminous source, it is convenient to divide up the advancing wave front into small portions known as half period elements or zones. Let b be the perpendicular distance from the given point to the wave front. Then if λ be the wave length of the light in question, a curve may be drawn on the wave front through all the points whose distance from the given point is $b + \frac{1}{2}\lambda$. The area included in this curve is the first half period element. Let the process be repeated for points whose distances from the given point are $b + \frac{2\lambda}{2}$, $b + \frac{3\lambda}{2}$, etc., in this way marking out a series of annuli which constitute the second, third, fourth, etc., elements. In the case of a spherical wave, these elements are all of equal area, and their usefulness depends upon the fact that the wave disturbance at the given point due to any element is, on the whole, in opposition to the effect of the next consecutive element, and thus the effect of the whole wave can be expressed in terms of these half period components.

Half Plain Work (*Build.*) The labour expended on the bed and side joints in stone walling.

Half Plate (*Photo.*) A plate measuring $6\frac{1}{2}$ in. by $4\frac{3}{4}$ in.

Half Portees (*Silk Manufac.*) *See* PORTEE.

Half Rip Saw (*Carp. and Join.*) A saw used by joiners for cutting wood in the direction of its fibres. It has about three to four and a half teeth to the inch. *See* SAWS.

Half Round File (*Eng.*) A file flat on one side and convex on the other.

Half Secret Dovetail (*Join.*) A dovetail of the form used in a drawer front; it is concealed in a front view, but visible in the side of the drawer when drawn out.

Half Shrouding (*Eng.*) A flange on a spur wheel which extends up to the pitch line, or half the depth of the teeth. *See also* SHROUDING.

Half Space (*Carp. and Join.*) A landing equal in size to the width of the staircase.

Half Stuff (*Paper Manufac.*) A name given to partially beaten pulp obtained during the manufacture of paper.

Half Timbered Work (*Build.*) Buildings in which the walls are formed of frames of timber, the panels being filled in with brickwork. *See also* FRAME HOUSES.

Half Tint. *See* HALF TONE.

Half Title (*Typog.*) The sub-title: it precedes the full title in a book.

Half Tone (*Art*). A tone intermediate between the most marked tones in a picture, etc., *i.e.* between the extreme lights and the extreme shadows; the lighter shadows of a picture, photograph, etc.

Half Tone Block. *See under* PROCESS WORK.

Half Wave Plate (*Light*). A plate of doubly refracting crystal, capable of splitting up a plane polarised ray into two portions, one of which is retarded half a wave length with respect to the other.

Hall Effect (*Phys.*) Suppose a steady current is flowing through a very thin metal plate, and let two points, transversal to the line of flow, be connected to a galvanometer. These points of contact can be adjusted until there is no deflection, showing that they are on the same equipotential line. Hall discovered that under these circumstances a deflection of the galvanometer is produced if the plate be placed in a strong magnetic field at right angles to the lines of force, which shows that an alteration takes place on the stream lines of current in the plate. The direction of the transverse E.M.F., which produces this effect, varies with the metal used; in iron, antimony, and zinc its direction coincides with the direction of the mechanical force exerted by the field upon the plate carrying the current, and the opposite is the case in bismuth, gold, and nickel. The magnitude of the E.M.F. is proportional to the strength of current in the plate, to the strength of the magnetic field, and inversely proportional to the thickness of the plate, and in any case is small and difficult to observe. The effect is almost certainly due to the deflection of the moving carriers of the current or "electrons" (*q.v.*), and is intrinsically the same as the more easily observed deflection of the "cathode rays" by a magnetic field.

Halogens (*Chem.*) The four elements, FLUORINE, CHLORINE, BROMINE, and IODINE are called the HALOGENS. They all form salts with sodium and potassium, and these salts bear a resemblance to sodium chloride, hence the name, which means literally sea-salt producers.

Haloid Salts (*Chem.*) The fluorides, chlorides, bromides, and iodides of the metals. In organic chemistry the compounds formed by the union of the halogens with alcohol radicals are often called HALOID ESTERS.

Halos (*Meteorol.*) Large circles formed round the moon or sun when viewed through light clouds. They are due to refraction, and may be either white or prismatic (rainbow coloured). Sometimes bright circles are formed on them, termed MOCK SUNS or PARHELIA, and MOCK MOONS or PARASELENÆ.

Halving (*Carp., etc.*) *See* HALF LAP JOINT.

Hamamelidaceæ (*Botany*). A subtropical natural order allied to the *Rosaceæ*. Its species yield woods (*Liquidambar*), resins (*Storax*), and medicinal products (*Hamameli*, witch hazel). *See also* SATIN WALNUT, *under* WOODS.

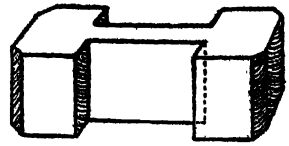
Ham Hill Stone. *See* BUILDING STONE.

Hammer. *See* HAMMERS.

Hammer Beam (*Carp. and Join.*) *See* ROOFS.

Hammer Dressed (*Build.*) Stones roughly shaped with a hammer at the quarry.

Hammer Headed Key (*Carp. and Join.*) A key with a projection for wedging. Its general form is as shown in the figure.



HAMMER HEADED KEY.

Hammerman (*Eng., etc.*) (1) The workman who manipulates the steam hammer in a forge. (2) An assistant to a smith, who uses a double handed or sledge hammer. (3) One of a set of men in a coal mine who fall the coal by means of wedges driven into holes. Also known as a DRIVER.

Hammers. A hammer consists of a suitably shaped HEAD of iron, steel, or iron faced with steel, provided with a handle or shaft of ash, lancewood, or some similar wood possessing strong springy fibres. Hammers vary in size, from those used by watchmakers up to the heavy sledge hammer weighing 14 lbs. or more. The most usual form has a flat surface or FACE at one end of the head, used for striking a blow; the other end of the head is formed into a PANE (also termed PEEN, PENE, or PIN), and is modified into many different forms for special purposes. A and B (fig. 1) are ordinary JOINERS'

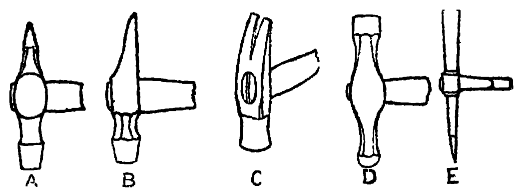


FIG. 1.

HAMMERS; C is a CLAW HAMMER, in which the pane is formed into a claw possessing a V-shaped slot used for drawing out nails. D and G are hammers with a BALL PANE, used by engineers and smiths. E is a form used by upholsterers; various modifications of this form are also used in allied trades. F is a DOUBLE HEADED HAMMER, used for

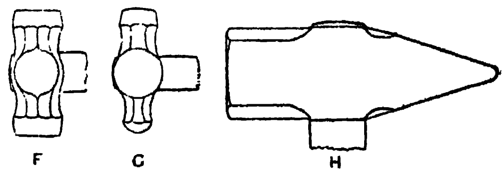


FIG. 2.

many different purposes, *e.g.* by joiners for driving home the tenons in a piece of framing, and termed by them a FRAMING HAMMER. H is a SLEDGE HAMMER, which may be made double headed, or may have a pane with its edge parallel to the handle (STRAIGHT PANE) or at right angles to the handle (CROSS PANE). A sledge hammer is provided with a long handle, and is usually wielded by a hammerman or striker, who uses both hands to swing it, the tool or work which is to be struck being held and manipulated by the smith or other workman. In addition to the hammers here described, a variety of forms are used by tin and copper-smiths, artistic workers in metal, and in many other arts and trades.

Hammer Scale (*Eng.*) The oxides of iron formed on the surface of iron in the forge, rolling mills, etc. The scale contains two oxides, FeO and Fe_2O_3, in varying proportions.

Hanap (*Archæol.*) A mediæval wine cup or goblet, often made of precious metal highly decorated.

Hand (*Her.*) A charge often borne in heraldry. The Badge of Ulster is a bloody hand. *See* ULSTER.

Hand Camera (*Photo.*) A camera that is held in the hand while photographing the subject. Fitted with a quick acting lens and shutter, and provided with either a set of dark slides, roll film holder, or a receptacle capable of containing plates or films, and a device for changing these after each successive exposure without the use of a dark-room.

Hand Feed (*Eng.*) The regulation of the rate of cutting in machine tools by the hand of the operator, as opposed to automatic or POWER FEED.

Hand Float (*Plast.*) A rectangular wooden blade with a "hand" fixed to it. Used for "floating," *i.e.* levelling and smoothing the surface in plastering.

Hand Holes (*Eng.*) Small holes in boilers, etc., through which the hand can be inserted for cleaning out the interior.

Hand Ladle (*Foundry*). A ladle for carrying molten iron; small enough to be carried by one man, and holding about fifty pounds weight of iron.

Hand Letters (*Bind.*) Alphabets of letters cut on brass stems set in wooden handles for "lettering" or placing the titles on the backs of books. They are used singly, but brass type can be set in a line.

Hand Machines (*Eng.*, *etc.*) Small machines driven by hand as distinguished from those driven by power.

Hand Made Paper. Paper made entirely by hand. It is of better quality and more expensive than machine made paper. *See* PAPER MANUFACTURE.

Handrail (*Joinery*). The rail running along a staircase, landing, etc. Handrails are spoken of as RIGHT or LEFT, according to which hand rests naturally on the rail when *ascending* the staircase.

Handrailing (*Joinery*). (1) A HANDRAIL (*q.v.*) (2) The process of designing and constructing handrails.

Handrail Punch. A punch for tightening up a handrail screw (*q.v.*)

Handrail Screw (*Joinery*). A small screw or bolt used in making a joint between two lengths of handrail. The nut is cylindrical, and possesses grooves or notches in its periphery, into which a handrail punch is inserted through an opening in the undersurface of the rail, in order to turn the nut and screw it up so as to make a tight joint.

Hand Rest (*Eng.*) The T-shaped rest for supporting hand-turning tools in working at a lathe when a slide rest is not used.

Hand Roller (*Typog.*) The roller sometimes used to ink type by hand when pulling a proof.

Hand Saw. A carpenter's tool for cutting timber across its fibres (grain). It has about five teeth to the inch. *See* SAWS.

Hand Screw (*Joinery*, *etc.*) A wooden cramp worked by two handles with threads on them. Used for holding glued work in position while the glue is setting.

Hand Tools (*Eng.*) Those which can be held in the hand or which are actuated by hand.

Hanger *or* **Hang Down** (*Eng.*) A frame for suspending a bearing from a roof or beam.

—— (*Foundry*). The sling which supports heavy weights in the foundry; the upper ends of the rods of the sling are attached to the travelling crane.

Hanging Committee (*Art*). A committee charged with the duty of hanging the pictures selected for an exhibition. At the Royal Academy the hanging committee consists of eight Academicians, including one sculptor and one architect.

Hanging Steps (*Build.*) Stone steps having one end built into a wall.

Hanging Style (*Carp. and Join.*) The style of a door which has the hinges fixed on to it.

Hank (*Linen Manufac.*) A hank is a bunch of reeled yarn, usually containing 12 cuts of 300 yards each in Ireland; in England 10 cuts of 300 yards are made up as hanks. *See* CUT.

—— (*Textile Manufac.*) The number of yards which determines the counts or thickness of a thread. COTTON and SPUN SILK HANKS contain 840 yards; a WORSTED HANK, 560 yards.

Hannay's White Lead (*Dec.*) A brilliant white pigment almost non-poisonous. It is produced in the form of a very fine powder direct from galena or lead ore. Made by volatilising the galena and passing it through oxidising chambers, whence lead sulphate is formed in fumes. The pigment is claimed to possess superior qualities to ordinary white lead (*q.v.*) made by the Dutch Process.

Harbour (*Civil Eng.*) An anchorage for ships, usually formed by a natural opening in the coast line, protected if necessary by artificial barriers or breakwaters.

Hard Brass (*Met.*) Brass which has not been annealed, or which has been hammered; it is much more elastic than soft or annealed brass.

Hard Core (*Build.*) Broken bricks, etc., used for filling up cavities, the foundations of roads, and similar purposes.

Hardening (*Met.*) Applied to steel it refers to the process of heating and sudden cooling which gives the maximum amount of hardness to the metal. This is afterwards modified by TEMPERING (*q.v.*)

Hardening Liquids (*Eng.*) The liquids used in cooling steel to harden it. Pure water, oils, and water with various salts dissolved in it are used; the advantages of the latter are very doubtful.

Hard Iron (*Eng.*) Castings of suitable brands of pig iron, mixed with scrap iron, can be made specially hard for use in parts of machines subject to much friction and wearing, such as wheel teeth.

Hard Kiln (*Pottery*). This is of the form of the enamel kiln, *viz.* muffle, but it is fired at a temperature between that of the enamel kiln and the glost oven.

Hard Lead (*Eng.*, *etc.*) Lead containing various impurities (antimony, etc.) becomes much harder than pure lead, and is useless for many purposes.

Hardness (*Min.*) The hardness of a mineral is determined by noting which of the standard minerals

the specimen may be scratched by, and which of the ten it will scratch. The standards are:

(1) Talc.	(6) Felspar.
(2) Gypsum.	(7) Quartz.
(3) Calcite.	(8) Topaz.
(4) Fluorspar.	(9) Sapphire.
(5) Apatite.	(10) Diamond.

Hardness (of Water). *See* WATER, CALCIUM COMPOUNDS, CLARK'S PROCESS, *and under* SANITATION.

Hard Packing (*Typog.*) A system of "making ready" (*q.v.*) which dispenses with the blanket, and is chiefly employed in printing on calendered papers. Illustrated magazines are generally printed by this system.

Hard Paste (*Pottery*). The term "Hard Paste" implies the reverse of Soft Paste. The body is more natural in its composition. The bisque is burned at a low temperature, leaving it porous and non-translucent. After glazing it is burned at a high temperature, which melts the glaze into the body. The body is thus rendered *non-porous* and *translucent*; the glaze is "hard" and is absorbed into the body.

Hard Paviors (*Build.*) Malm bricks, over-burnt and slightly blemished in colour, used for paving, coping, etc.

Hard Solder (*Eng., etc.*) Various alloys containing silver, copper, zinc, etc., used in brazing (*q.v.*), in soldering jewellers' work, and other purposes where a very close, neat, and strong joint is required. The difference between hard and soft solders is chiefly due to the absence of lead in the former: consequently the melting point of hard solders is much higher.

Hard Stock. *See* BRICKS.

Hard Water. *See* WATER, CALCIUM COMPOUNDS, CLARK'S PROCESS, *and under* SANITATION.

Hard Woods (*Carp., etc.*) This term is loosely applied to most woods, other than the coniferous woods (pine, deal, etc.), but it has no exact significance. *See* WOODS.

Hargreave's Process (*Chem.*) A process for the direct conversion of common salt into sodium sulphate without the intervention of sulphuric acid. Sulphur dioxide, air, and steam are passed over cakes of common salt contained in iron cylinders, kept at a temperature of about 500° C. The gases are passed over the salt in such a manner that the freshly introduced gas comes in contact with salt which is nearly converted; and the gases which are nearly used up, with fresh salt. The sulphur dioxide is obtained by burning iron pyrites.

Harmonic Curve (*Phys.*) The curve obtained when simple harmonic motion is represented by plotting time as abscissæ and displacements from zero position as ordinates. It may also be defined as the curve obtained by compounding a S.H.M. in a given direction with a uniform linear motion in a perpendicular direction. The simplest form of the equation to the curve is $y = a \sin bx$, where a represents the maximum amplitude and $\frac{2\pi}{b}$ the periodic time, and hence it is known as a "sine" curve. Its great importance and usefulness depend on the fact (discovered by Fourier) that any periodic curve whatever may be analysed into a series of superposed harmonic curves, and thus made amenable to calculation. *See* FOURIER'S SERIES *and* HARMONIC MOTION.

Harmonic Law (*Astron.*) The name of the third law of motion discovered by Kepler in the seventeenth century; namely, the squares of the periods of the planets are proportional to the cubes of their mean distances from the sun.

Harmonic Motion, Simple (*Phys.*) A type of oscillatory motion deriving its name from its very general occurrence in the vibrations of bodies emitting musical sounds when the amplitude is not too great. It is completely defined by the two conditions: (1) the acceleration of the moving mass is proportional to its displacement; (2) the acceleration is always acting towards the position of rest. The time of one complete vibration is given by $T = 2\pi\sqrt{\frac{\text{Displacement}}{\text{Acceleration}}}$, and above definitions show that this is a constant quantity. As instances of motions of this type may be mentioned the point of the prong of a tuning fork, or a point in a vibrating string; vibrations of a weight suspended by a spring; oscillations of a pendulum, etc.; it being assumed in each case that the amplitude is small. The resultant of two harmonic motions at right angles, of the same period and amplitude, but differing in phase by a quarter of a period, is a uniform circular motion, and hence arises a simple method of representation. For if a point P (fig. 1) be supposed to move with uniform velocity in a circle (termed the CIRCLE OF REFERENCE) whose radius OA is equal to the AMPLITUDE of the vibration (where amplitude = maximum displacement from position of rest), the point X, or foot of the perpendicular from this point upon the diameter AB, moves backwards and forwards with a simple harmonic motion in the time of one complete revolution of P: this time is termed the PERIODIC TIME, and usually denoted by T. We may express the same facts in mathematical symbols as follows: The distance OX (which may be denoted by x), termed the DISPLACEMENT, is equal to OA cos AOP, or $r \cos \theta$. Now θ is the angle through which the line OP has turned in a given time; let this time be t, and let the angular velocity of OP be ω. Then $\theta = \omega t$, and $x = r \cos \omega t$. The displacement may therefore be represented by a curve, of which the abscissa is proportioned to t and the ordinate to $\cos \omega t$. A similar curve in which the ordinate is proportional to Sin ωt is shown in fig. 2.

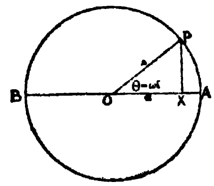


FIG. 1.

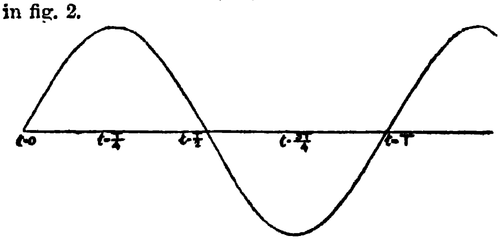


FIG. 2.

The displacement is zero when $t = 0$; it increases to a maximum which is equal to r, the amplitude, when $t = \frac{T}{4}$ (that is, after a quarter of a revolution of the

point P), and falls to zero again when $t = \frac{T}{2}$, or when P is at B (fig. 1), and then attains the value $-r$ when $t = \frac{3T}{4}$, returning to zero after an interval T, when P has again reached A. This curve is a SINE CURVE (or COSINE CURVE). The angle which OP makes at any given instant with some arbitrary fixed line is termed the PHASE of the point which is executing the simple harmonic vibration. Thus if we take OA as the fixed line, the phase of the point X is the angle POA, which equals θ or ωt.

Harmonics (*Music*). (1) The series of constituent sounds of higher pitch which are produced with more or less completeness along with a musical tone, and which play an important part in determining the "quality" of musical tones. They are also called "overtones" or "upper partials." These harmonics are given forth in a regular progressive series, each note being of less intensity than the preceding. In the following table of the first 19 harmonics produced from the note D it will be seen that the vibration ratio of each note is one half that of its octave:

The harmonics given off by the $\frac{1}{7}$th and $\frac{1}{14}$th of the whole string are slightly flatter, and that given by the $\frac{1}{11}$th sharper, than the corresponding exact note of the key. (This table is taken from Professor Prout's *Harmony*, chap. ii.) This series of harmonics may be produced theoretically along with every note, and by transposing this table according to the generator required the series may be found from that note. (2) Upper notes produced on stringed instruments—(*a*) by slightly pressing the finger on the open string at the various "nodes," *i.e.* points of rest in a vibrating string. These are termed NATURAL HARMONICS. (*b*) By stopping the string with the first or second finger, and then slightly pressing the node with the fourth finger. These are termed ARTIFICIAL HARMONICS. These harmonics are written in diamond shaped notes.

—— (*Phys.*) In almost all cases of vibration it is more or less difficult to obtain a single definite frequency. As a rule, smaller vibrations are present superposed upon the original or fundamental. These are known as the "harmonics," and first acquired importance in the theory of sound and of music. It is now usual to define the harmonics of any vibration as a series of vibrations having frequencies 1, 2, 3, 4, 5, etc., times the frequency of the given vibration or fundamental. This is in accordance with the mathematical treatment due to Fourier, who showed how to resolve any complicated periodic vibration into an infinite series of harmonic vibrations having the above frequencies, although in practical calculations a few terms are usually sufficient. Sometimes, as in the case of a closed organ pipe or an alternating electric current, only the odd harmonics can exist. When the possible higher frequencies are not simple multiples of the fundamental (as in vibrating rods, tuning fork, etc.), they are called "overtones" or "upper partials." It must not be supposed that all or any of the possible harmonics are actually present in a given case. That depends upon the nature of the vibrating substance and the way it is set in vibration; for instance, in strings it depends upon the point struck.

Harmonium (*Music*). *See* MUSICAL INSTRUMENTS—WIND (KEYED).

Harmony (*Music*). (1) An orderly succession of different combined sounds. (2) The study of chord building from "roots," and of connecting these chords in their different positions, having regard to key relationship.

Harness (*Silk Manufac.*) A collection of two or more HEDDLES (*q.v.*), healds, lames, or shafts used for making satin, twill, or other plain cloths.

—— (*Textile Manufac.*) In a Jacquard machine the group of cords carrying the MAILS (*q.v.*) through which the threads of warp pass. The depression of the cords is effected by each carrying a separate weight or lingo. These serve the same purpose as the heddles for tappet or dobby.

Harp (*Her.*) The national device of Ireland. It is borne in the Irish quarter of the Royal Arms of Great Britain.

—— (*Music*). *See* MUSICAL INSTRUMENTS, STRINGED (2).

—— *See* MUSICAL INSTRUMENTS—STRING (BY HAND).

Harp Pendant (*Gas Fitting*). A gas pendant in the form of a loop with the burner in the centre.

Harpsichord (*Music*). A precursor of the pianoforte, being a keyed instrument played by means of plectrums set in motion by the keys. A fine collection may be seen in the Victoria and Albert Museum, South Kensington.

Harpy (*Her.*) A fabulous heraldic creature represented as a vulture with a woman's head and neck.

Harrison's Gridiron Pendulum. *See* PENDULUMS.

Harrock Hill Stone. *See* BUILDING STONES.

Hart (*Her.*) A stag of full growth with branching horns. Borne as a charge or a crest. The female represented without horns is called a HIND.

Harvest Moon (*Astron.*) About the autumnal equinox and harvest time in England the moon, when full, possesses its minimum retardation, *i.e.* rises more nearly at the same time on successive nights than at other times of the year. It is then termed the harvest moon, for, rising at sunset, it affords aid to harvesters who have not ended their day's work.

Hat (*Her.*) A cardinal's hat is generally represented in the arms of an ecclesiastic who belongs to that princely order in the Church of Rome. It is red, with wide brim and pendent tassels.

Hatched Moulding (*Architect.*) A simple enriched moulding used in Norman work, generally as a string course. The moulding has a half-hexagonal projection; squares are marked out on the projecting faces, and the triangle below the diagonal of each square is slightly sunk.

Hatchet (*Carp., etc.*) A small axe.

—— (*Her.*) An ancient charge. William de Hursthelve in the thirteenth century blazoned azure, three hatchets argent.

Hatchet Stake (*Eng.*) A flat plate of metal with a sharp edge, fixed in a vertical position for bending sheet metal over.

Hatching (*Art*). A series of parallel lines, or several series crossing, employed in drawing and engraving to produce the effect of shading and so indicate the modelling of an object, tones, etc.

Hatchment (*Her.*) The achievement or armorial bearings of a person deceased. Sometimes hung outside the house where such person lived, and afterwards placed in the church near the family pew.

Hathor Headed Capital (*Architect.*) A form of capital used in Egyptian architecture. In this capital, a block of stone, carved on each face with a representation of the head of the Goddess Isis, and supporting a model of a temple, is introduced above a Campaniform capital. It is also known as the ISIS HEADED CAPITAL. *See* CAMPANIFORM CAPITAL, CLUSTERED LOTUS CAPITAL, LOTUS CAPITAL, *and* PALM CAPITAL.

Hat Leather (*Eng.*) A leather ring used as packing for hydraulic rams, etc. Its section is in the form of the letter L.

Hauberk (*Armour*). A long coat or tunic of mail used in the middle ages. Originally it was only intended to protect the neck and shoulders. *See* ARMOUR *and* MAIL.

Haulm (*Botany*). *See* CULM.

Haunch (*Build.*) The portion of an arch between the crown and springing. *See* ARCH.

Haunched Tenon (*Carp. and Join.*) A tenon cut back in its width to allow for wedging.

Hauptwerke (*Music*). The German name for Great Organ. *See* ORGAN.

Hauriant (*Her.*) "Paleways" or "in pale," and having the head in chief. Used to describe the position of a fish on a field, when it appears as if rising to the surface of the water for breathing. The converse is URIANT.

Hausmannite (*Min.*) Mangano-manganic oxide, Mn_3O_4. Manganese = 72·1, oxygen = 27·9 per cent. Occurs in small black tetragonal octahedra, which have a brown streak. From Thuringia, the Harz, United States, West Cumberland, etc.

Hautboy (*Music*). The French term for OBOE (*q.v.*)

Hawk (*Her.*) A bird of prey frequently used in heraldry. It is blazoned "belled," "jessed," and "varvelled." Varvelles are small rings attached to the jesses.

—— (*Plast.*) A square piece of board with a handle in the centre underneath. Used for holding a supply of plaster while it is being laid on a wall or ceiling.

Hawk Bells *and* **Jesses** (*Her.*) The small round bells attached to the legs of hawks. Hawks' jesses are the short leathern thongs fastened to each leg of a hawk and to which the leash held by the falconer is attached.

Hawser Pipe *or* **Hawse Pipe** (*Eng.*) (1) The hole through which a ship's cable runs out. (2) A similar opening through which the chain runs in some cranes.

Hawthorn. *See* WOODS.

Hay Band (*Foundry*). Roughly made ropes of hay wound round an iron bar, on which loam is to be placed to form a large CORE (*q.v.*) The hay serves to form a porous interior in the core, through which gases can escape when the hot metal comes in contact with the outside.

Hazel. *See* WOODS.

Hazel Nut Oil. A pale yellow inodorous oil obtained by expressing the fruit of *Corylus avellana.* The product is limited. It is used, when fresh, for cooking purposes, also for burning and for soap making.

Hazel Rods (*Eng.*) Thin rods of hazel are often used for the handles of smiths' tools (chisels, punches, etc.) which have to be struck by a hammer.

He (*Chem.*) The symbol for HELIUM (*q.v.*)

Head (*Build.*) (1) The end of a quoin stone. (2) The top end of a slate when fixed on a roof.

—— (*Carp. and Join.*) The top of a door frame; the top end of a shore, etc.

—— (*Cycles*). The socket or hollow tube through which the tube carrying the front forks runs. It has ball bearings at the top and bottom in most machines.

—— (*Eng.*) (1) The top of a tool or other object. (2) The depth or height of water in a vessel, which determines the pressure at any given point below the surface.

—— (*Typog. and Bind.*) The top part or margin of a page.

Head and Tail (*Bind.*) The head is the top of a book; the tail is the bottom.

Head Band (*Bind.*) The head band is the little ornamental accessory fixed to the head and tail of a volume inside the back, to give a finished appearance. Formerly they were worked in different coloured silks very carefully attached to the book itself, but now they can be bought ready made by the yard, and are glued on.

Header (*Build.*) A brick or stone with its end showing on the face of the wall, *i.e.* one with its longer axis at right angles to the plane of the wall.

Heading Course (*Build.*) A course of headers. *See* ENGLISH BOND.

Heading Joint (*Carp. and Join.*) Two floor boards joined end to end. *See* FLOORS.

Headington Stone. *See* BUILDING STONES.

Heading Tool (*Eng.*) A tool used for forming the heads of bolts, large nails, etc., when forged by hand.

Headline (*Typog.*) The heading (top line) on the page of a book.

Head Metal (*Foundry*). A kind of reservoir of metal connected with the interior of a mould by a gate (*q.v.*) or runner, or else opening directly into the mould itself. The scum, etc., rises into the head, leaving the casting sound; when the casting is removed the unsound metal forming the head is cut off.

Head Nailed (*Build.*) Slates fixed at the top end.

Headon Beds (*Geol.*) Rocks of fluvio-marine origin which were formed in the south of England during the Oligocene Period. They are best developed in the Isle of Wight and the maritime areas to the north-west of that district.

Head Room (*Carp. and Join.*) The vertical height of a landing trimmer above the stairs.

Headstock (*Eng.*) The part of a lathe which contains the MANDREL (*q.v.*)

—— (*Textile Manufac.*) The principal part of the self-actor or spinning mule. It consists of the mechanism for controlling the several motions, such as the delivery of the sliver, twisting, the drawing out and winding up of the carriage, and the winding up of the spun yarn on to the cop or bobbin.

Head Valve (*Eng.*) An upper valve of a pump; the lower valve is termed a FOOT VALVE.

Heald (*Textile Manufac.*) *See* HEDDLE.

Heart Cam (*Watches*). A heart-shaped piece used in split seconds work, chronographs, and other mechanisms where the parts are required to return to their original positions at the will of the operator. *See* SPLIT SECONDS CHRONOGRAPH.

Hearth (*Build.*) The cemented, tiled, or paved floor of a fireplace : the part of the floor which lies beneath and in front of the grate.

—— (*Eng.*) (1) The lower part or base of a furnace or the part containing the fire. (2) The part of a forge containing the fire.

Heart Wood (*Carp., etc.*) The wood forming the central part of the trunk of a tree.

Heat. A term used to denote the sensation of warmth, and also the physical cause of that sensation. From the latter point of view heat is now regarded as being a kind of molecular vibration or motion, and hence a form of energy.

—— (*Eng.*) The term is used in engineering and other trades in various senses, in addition to the correct scientific one. Thus it is applied to (1) the temperature at which an operation is carried out, *e.g.* WELDING HEAT; (2) the process of heating materials to such a temperature; (3) the amount of material dealt with at one time or in one single operation.

——, **Atomic** (*Chem.*) *See* ATOMIC HEAT.

——, **Conduction of** (*Phys.*) *See* CONDUCTIVITY, CONDUCTION OF HEAT, *etc.*

Heat Equator (*Meteorol.*) Owing to the great extent of land in the Northern Hemisphere the highest mean annual temperature of the parallels of latitude is found at latitude 10° N.

Heating Apparatus (*Eng.*) Radiating apparatus by which heat is distributed to warm a building by hot water, air, or steam. Occasionally electric heaters are employed; they have the advantage that heat can be given out at a point considerably removed from the source, without as much loss at intermediate points as occurs with the methods previously mentioned.

Heating of Bearings (*Eng.*) Bearings when not sufficiently lubricated become very hot; they then become very much worn, or the surfaces in contact may adhere, and a fracture may occur. In large installations of machinery it is often found advisable to keep one man entirely employed in looking after the bearings to prevent heating; this is usually done, for example, on a large steamship.

Heating of Buildings. *See under* SANITATION.

Heating Surface (*Eng.*) The area of a boiler, including flues and tubes, which is in contact with the fire or the hot gases.

Heat, Latent (*Phys.*) *See* LATENT HEAT.

——, **Mechanical Equivalent of** (*Phys.*) *See* MECHANICAL EQUIVALENT OF HEAT.

——, **Molecular** (*Phys.*) *See* MOLECULAR HEAT.

Heat of Combustion (*Chem.*) The amount of heat evolved, expressed in calories (*q.v.*), when the molecular weight, taken in grams, of any substance is completely burned. In the case of elements, that quantity is taken which will give one gram-molecule (*q.v.*) of the product. Thus in the case of acetic acid ($C_2H_4O_2$) the heat of combustion is the number of calories evolved when 60 grams (60 being the molecular weight) are completely burned to water and carbon dioxide. But in the case of carbon, whose molecular weight is unknown, the heat of combustion is the number of calories evolved when 12 grams are completely burnt to 44 grams (the molecular weight) of carbon dioxide. *See also* THERMOCHEMISTRY.

Heat of Formation (*Chem.*) The heat (expressed in calories) evolved or absorbed in the production of the gram molecular weight of a substance from its elements. *See also* THERMOCHEMISTRY.

Heat of Ionisation (*Phys.*) The internal energy of a substance in its neutral state is not necessarily the same as its energy when in the ionised state, and the difference may be positive or negative. This difference is known as the HEAT OF IONISATION.

Heat of Solution (*Phys.*) The total amount of heat which is either absorbed or set free by dissolving one gram of a substance in a given solvent.

Heat, Radiant. *See* RADIANT HEAT.

Heat Radiator (*Motor Cars*). A device by which the cooling of the cylinder of a motor cycle or of the condenser of a car is promoted. A series of flanges or "gills" are attached to the tubes of a condenser (or cast on the body of a cylinder); these become heated by conduction, and dissipate the heat into the atmosphere by radiation.

Heat, Specific. *See* SPECIFIC HEAT.

——, **Unit of.** The heat necessary to raise unit mass of water through unit rise of temperature (1°). The English engineer uses the pound and the degree Fahrenheit as the respective units: in scientific work it is usual to employ the CALORIE (*q.v.*)

Heaume (*Armour*). *See* HELM.

Heaves (*Geol.*) A miner's term for the lateral shift of a fault or lode which has been produced by the action of a fault of *later* date. An allied phenomenon of considerable importance in connection with metalliferous veins is that in which a newer fault or lode traversing an older one has been deflected by the older line of weakness. Many dykes have been TRAILED (as this deflection is termed) by this cause.

Heavy Oil (*Chem.*) That fraction of coal tar which distils between 230° and 270° C. It is used under the name of CREOSOTE. *See* GAS MANUFACTURE (COAL TAR DISTILLATION).

Heavy Spar (*Min.*) A synonym for BARYTES (*q.v.*)

Heck (*Cotton Manufac.*) A framework carrying needles by which a lease is formed when "warping."

Hecto-. A prefix used in the metric system to denote a multiple of one hundred times the measure to which the prefix is applied; *i.e.* hectolitre, one hundred litres. *See* WEIGHTS AND MEASURES.

Heddle (*Textile Manufac.*) The Scotch term for HEALD-SHAFT. Heddles consist of upper and lower wooden shafts or laths fastened together by HEALD CORDS, which contain in the centre a MAIL or EYE, through which the threads of warp are passed separately. Each pair of laths or staves are under separate control by the TAPPET or DOBBY, and thus the warp threads are raised or depressed to interlace with the weft as it is shot across in the loom.

——, **Heald, Lame,** *or* **Shaft** (*Silk Manufac.*) Two flat sticks called VERGEES, placed parallel about 15 in. apart, connected by a series of fine cotton threads, each having in the middle a loop or eye to receive the warp thread. In the "Grob" system, lengths of flattened steel wire perforated in the centre for the eye replace the cotton thread.

Heddon Stone. *See* BUILDING STONES.

Heel Ball. A composition of carnauba wax, resin, blacking, and paraffin wax, used for rubbing on the heels and sides of the soles of boots to give a finish.

Heel Strap (*Carp. and Join.*) The iron band securing the foot of the principal rafter to the tie-beam.

Heel Tool (*Eng.*) An old form of hand-turning tool used in taking a heavy cut. It had a bend or heel near the cutting end which rested on the top of the T-rest. A similar cut is usually taken by a slide rest tool in modern lathes.

Height of Barometer. The length of a vertical column of mercury whose pressure is equal to that of the atmosphere. *See* BAROMETER.

Heliacal Rising *or* **Setting** (*Astron.*) The rising or setting of a celestial body just before sunrise or just after sunset.

Helianthin (*Chem.*) METHYL ORANGE (*q.v.*)

Helianthus (*Botany*). A well known genus of the order *Compositæ*. *H. annuus* is the sunflower, whose seeds yield a useful oil; *H. tuberosus* is the Jerusalem artichoke.

Helical Gear (*Eng.*) Gear wheels with teeth set at an angle with the axis of the wheel.

Helical Spring. A spring produced by winding a steel strip or wire on the surface of a cylinder; often erroneously called a "spiral spring." *Cf.* HELIX *and* SPIRAL.

Helical Tube (*Cycles*). A tube made of a long strip of steel wound on a cylindrical roller in the form of a helix (or so-called "spiral") and brazed at the edges into a continuous tube.

Heliograph. An instrument for signalling through considerable distances by means of a beam of sunlight. It consists of a small mirror mounted upon a suitable stand, and arranged so that the sun's light may be reflected to the distant station, where it can be observed as a luminous point by means of a telescope. The signals are then produced by a series of flashes.

—— (*Astron.*) An instrument, generally equatorially mounted, for photographing the sun.

Heliometer (*Astron.*) An equatorially mounted telescope, the object glass of which is diametrically divided into two parts, which are capable of sliding past each other.

Helioscope (*Astron.*) A special form of solar eyepiece used when observing the sun, in order to protect the eye from the intense brilliancy and heat of the rays.

Heliostat. An instrument for obtaining a beam of sunlight in an invariable direction for experimental purposes, etc. It consists essentially of a mirror provided with a clockwork motion which enables it to follow the apparent motion of the sun.

Heliotrope (*Min.*) A semi-translucent green variety of CHALCEDONY, spotted with red.

Helium (*Chem.*), He. Atomic weight, 4. A colourless gas; has not been liquefied; least soluble of all gases (100 vols. water dissolve ·73 vols. He). It has a monatomic molecule. Cannot be made to enter into chemical union with any other element or compound. Occurs in the sun, in the Earth's atmosphere to a small extent, and in certain rare minerals which contain uranium, thorium, yttrium. The minerals richest in helium are clèveite, uraninite, and bröggerite. From these it is obtained by heating under greatly reduced pressure. Other gases evolved at the same time are removed by suitable treatment: thus hydrogen is made to unite with oxygen to form water, and nitrogen is made to combine with heated magnesium. The spectrum of helium contains two lines exceedingly near together in the yellow; it was from the presence of this double line in the solar spectrum that this element was discovered in the sun thirty years before Professor Ramsay discovered it in the rare minerals referred to above. Helium has been used as a thermometric substance in measuring the very low temperatures at which hydrogen boils and solidifies. It is estimated that the boiling point of liquid helium will be about 5° above the absolute zero. *See also* RADIUM.

Helium Stars (*Astron.*) Stars the spectra of which show prominently the lines of the gas helium.

Helix. The curve produced when a line is wound regularly round the surface of a cylinder (or cone) so as to lie in that surface. The thread of a screw and a spring of the elongated form are examples.

Helm *or* **Heaume** (*Armour*). A helmet of great size and strength, used in the twelfth and thirteenth centuries. It was generally worn over a smaller head covering, *e.g.* the bascinet (*q.v.*), and reached down to the shoulders. *See also* ARMOUR.

Helmet (*Armour*). A general term for the defensive covering for the head. It varied in form during successive periods from the Chapelle-de-fer (*q.v.*) to the helmet worn at joust and in battle from the fourteenth to the sixteenth centuries. *See* HEAUME *and* ARMOUR.

—— *or* **Helm** (*Her.*) Used as an accessory above a shield of arms. It has various forms according to the period. It is placed above the shield resting upon the "chief." Commoners, knights, and baronets have their crests placed upon their helms, sustained by wreath, cap, or crest coronet. Peers and princes place their coronets upon the helm and their crest above the coronet. The helm of the sovereign and princes of the Blood Royal is of gold, and placed "affrontée," guarded with six bars; that of nobles of silver, placed in profile, with five bars; that of baronets and knights is of steel, "affrontée," vizor raised and without bars. Esquires and gentlemen, vizor is closed and placed in profile. Helmets are also borne as charges upon a field.

Helve. The handle or haft of a hammer.

Helve Hammer (*Eng.*) An obsolete form of mechanically worked hammer.

Helvetia Leather. *See* CROWN LEATHER.

Hematite (*Min.*) A synonym for HÆMATITE (*q.v.*)

Hemicrystalline Rocks (*Geol.*) These may be typified by basalt, a rock of eruptive origin, in which some of the constituent minerals had crystallised from solution before the fluid matrix began to consolidate. Hence these minerals are enclosed within a stony or lithoidal matrix which is usually devoid of crystalline structure. All lavas are necessarily hemicrystalline in structure.

Hemihedral Forms (*Min.*) Crystal forms in which alternate faces or alternate groups of faces of the holohedral forms (*q.v.*) are suppressed.

Hemimorphism (*Min.*) A condition where a doubly terminated crystal shows dissimilarity of forms at the opposite ends. It is well seen in Hemimorphite, in Greenockite, and in Epsom Salts.

Hemimorphite (*Min.*) Hydrous silicate of zinc, $ZnSiO_3 . 2H_2O$. Silica = 25·1, oxide of zinc = 67·4, water = 7·5 per cent. Orthorhombic, hemimorphic (*q.v.*); also massive. White, pale yellow to green and blue. Also called Smithsonite, and, by some American writers, Calamine. From Somerset, Derbyshire, Cumberland, Silesia, Hungary, the United States, etc.

Hemisphere. The half of a sphere cut off by a plane passing through the centre.

Hemp (*Botany*). The macerated bast fibres of *Cannabis sativa* (order, *Moraceæ*) yield a valuable material for ropes, etc. The seeds, oil, and a resin are also used.

Hempseed Oil. This is obtained by expressing the seed of *Cannabis sativa*. It is a greenish yellow when freshly pressed, but the greenish tint disappears when refined. It may be used for the same purposes as olive oil, as a burning oil, and for soap making. It is often employed to adulterate linseed oil, the effect of the addition being to retard the drying. The specific gravity at 15° C. is 0·925 to 0·930.

Henry's Law. (*Chem.*) The amount of a gas (by weight) which dissolves in a liquid varies directly with the pressure on the gas when the temperature is constant. This law only holds for the less soluble gases.

Heraldry. In the modern sense heraldry is the art of blazoning or describing armorial bearings. Formerly it dealt also with genealogy and precedence. Although probably of ancient origin, heraldry only assumed definite individual and hereditary character about the middle of the twelfth century, this being largely due to the increasing necessity for knights in full armour to bear some distinctive device for the purpose of identification. Between the twelfth and fifteenth centuries rules had been formulated for the blazoning of arms, the arrangement of devices, colours, etc.; and the science had become sufficiently systematised to warrant the establishment of an authority to regulate matters pertaining to the bearing of arms and the claims of descent. The Heralds College was accordingly constituted about 1425 by Edward III.

HERALDIC COLOURS OR TINCTURES.—There are a certain number of "tinctures" used in heraldry, both for the field or groundwork of a shield, and also for the various charges that may be placed upon it. They are of three kinds: metals, colours, and furs. Only two METALS are employed, *viz.* gold and silver, called respectively *or* and *argent*, the former represented in engraving by small dots, and the latter by a plain white surface. There are five COLOURS most commonly employed, besides one or two others rarely used:

1. Azure is *blue*, and represented by horizontal lines.
2. Gules is *red*, and represented by perpendicular lines.
3. Sable is *black*, and represented by horizontal and perpendicular lines crossing.
4. Vert is *green*, and represented by diagonal lines drawn from dexter chief to sinister base of the shield.
5. Purpure is *purple*, and represented by diagonal lines drawn from sinister chief to dexter base.
6. Tenné is *orange*, and represented by diagonal lines as vert, crossed by horizontal.
7. Sanguine is *blood colour* or *dark red*, and represented by diagonal lines as purpure, crossed by other diagonal lines as vert.

The FURS are eight in number, *viz.*

1. Ermine: A field "argent," powdered with spots "sable."
2. Ermines: The reverse of the former.
3. Erminois: A field "or" powdered "sable."
4. Pean: The reverse of the former.
5. Vair: The field covered with little shield shaped figures, argent and azure alternately.
6. Counter vair: When the small shields are arranged point to point and base to base.
7. Potent: The field covered with small potents or crutches, tincture like vair.
8. Counter potent: The potents placed point to point and base to base.

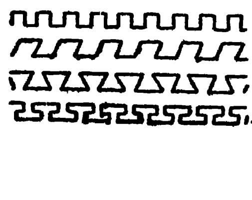
Metal should never be placed upon metal in charges, nor colour upon colour. Figures borne on a shield in their natural colours are described as "proper."

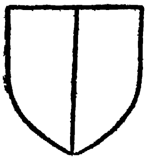
PARTITION LINES.—There are in general use the following methods of dividing a shield, *viz.*

1. By a perpendicular line, called *party per pale* or *impaled*.
2. A horizontal line across the middle, called *party per fesse*.
3. A perpendicular and horizontal line crossing, called *party per cross* or *quarterly*.
4. A diagonal line, called *party per bend*.
5. A diagonal both dexter and sinister, called *party per saltire*.
6. Two lines rising from opposite sides of the base and meeting in form of an acute angle at the fesse point, called *party per chevron*.
7. The latter with a perpendicular line to point of intersection, called *grafted* or *party per pale and chevron*.

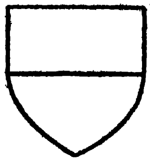
The dividing lines are either straight or assume the following ornamental forms:

Engrailed .
Invected .
Wavy or Undée
Nebulée .
Indented
Dancetté
Embattled
Ragulée .
Dovetail .
Potentée .

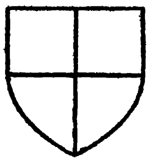




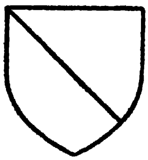
PER PALE.



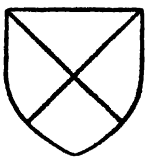
PER FESSE.



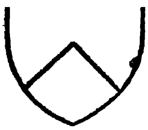
PER CROSS OR QUARTERLY.



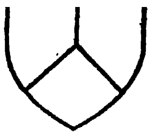
PER BEND.



PER SALTIRE.



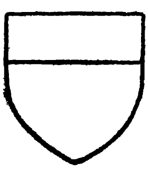
PER CHEVRON.



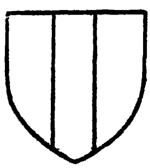
PER PALE AND CHEVRON.

CHARGES.—Whatever device is placed upon a shield it is called in heraldry a "charge." Charges are divided into three classes, *viz.* Honourable ordinaries, subordinaries, and common charges. They are called ordinaries from being used most ordinarily.

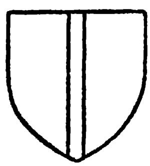
ORDINARIES.—The following are the honourable ordinaries and their diminutives:



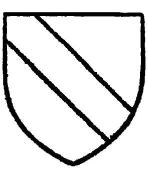
THE CHIEF.



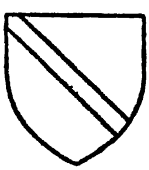
THE PALE.



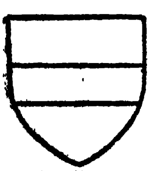
THE PALLET.



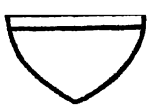
THE BEND.



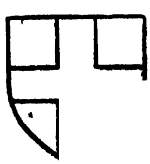
THE BENDLET.



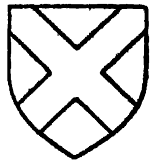
THE FESSE.



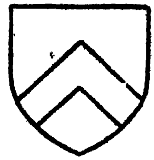
THE BAR.



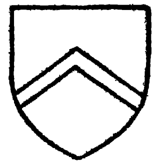
THE CROSS.



THE SALTIRE.

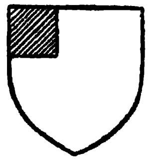


THE CHEVRON.

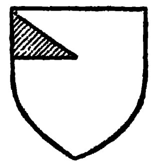


THE CHEVRONEL.

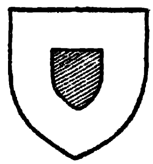
SUBORDINARIES.—There are some fifteen subordinaries; authorities differ as to the exact number. These, combined with ordinaries, and by means of partition lines and various charges, can be made to afford an almost infinite variety of coats of arms:



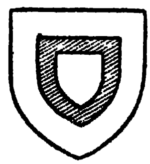
CANTON.



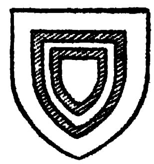
GYRON.



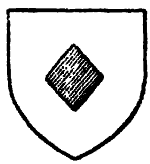
INESCUTCHEON.



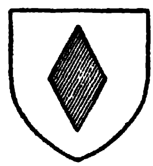
ORLE.



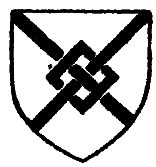
TRESSURE.



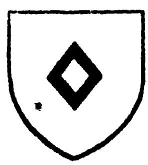
LOZENGE.



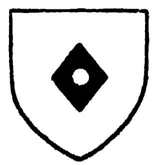
FUSIL.



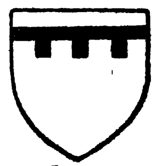
FRETTE.



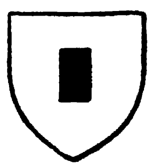
MASCLE.



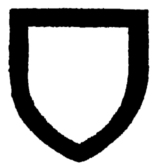
RUSTRE.



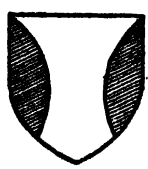
LABEL.



BILLET.



BORDURE.



FLANCHES.

FLASQUES OR VOIDERS.

See also ARMORIAL BEARINGS, COAT ARMOUR, *and* CROSS.

Herma, *pl.* **Hermæ** (*Archæol., Art*). A kind of statue consisting of a head or bust (generally that of the god Hermes) set on a quadrangular pillar. Used by the Greeks and Romans as boundary marks, decorative pillars, etc.

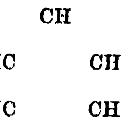
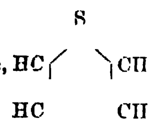
Herring (*Zool.*) *Clupea harengis* (family, *Clupeidæ*). A well known food fish found in the North Atlantic. The young of the herring form a greater part of whitebait.

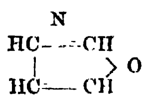
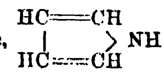
Herring Bone (*Architect., etc.*) A term applied to stones, bricks, or other small component parts of a structure, etc., set diagonally; the members of adjoining rows usually slope in opposite directions.

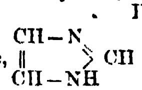
Herringbone Bond (*Build.*) A cross bond in the interior of thick walls.

Herringbone Strutting (*Carp. and Join.*) Cross strutting between floor joists.

Heterocyclic Compounds (*Chem.*) Ring compounds containing more than one element in the ring; *e.g.*

Pyridine,  Thiophene, 

Furfurane,  Pyrrole, 

Glyoxaline, 

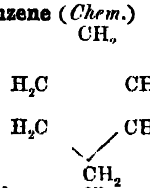
See also CLOSED CHAIN COMPOUNDS.

Heulandite (*Min.*) Hydrous silicate of aluminium and iron, $Al_2O_3 . 3SiO_2 + CaO . 3SiO_2 + 5 H_2O$. Monosymmetric. White, brownish to rich red. From Stirlingshire, Antrim, Iceland, India, etc.

Hevea (*Botany*). A genus of *Euphorbiaceæ* belonging to tropical America. It is the source of Para rubber.

Hewett's Mercury Vapour Lamp. *See* MERCURY VAPOUR LAMP.

Hexahydrobenzene (*Chem.*)



A liquid with benzene-like smell and a boiling point almost the same as benzene (81°). It occurs in Russian petroleum. Can be prepared by reducing benzene with hydriodic acid at a high temperature. *See also* NAPHTHENES.

Hexamethylene (*Chem.*) HEXAHYDROBENZENE (*q.v.*)

Hexastyle (*Architect.*) A term used to denote that form of temple which has six columns in the front row. *See* OCTASTYLE, TETRASTYLE, DISTYLE, *and* DECASTYLE.

Hexoses (*Chem.*) *See* SUGARS.

H Girder (*Eng.*) A wrought iron or steel girder whose cross section has somewhat the form of the letter H, with the horizontal stroke long in proportion to the vertical ones. Also termed an I girder.

Hickory. *See* WOODS.

Hides (*Zool.*) The skins of the horse, deer, sheep, pig, dog, etc., used in the manufacture of leather. The term is applied more particularly to the skins of large beasts that may be tanned into leather.

Hieroglyphics, Hieroglyphs (*Archæol.*) The characters used in writing by the ancient Egyptians (and other ancient races). They consisted of figures of animals and objects symbolising some word, syllable, or sound; picture writing.

High (*Typog.*) A term applied to type or blocks which stand out in front of the rest of the type in the forme; *e.g.* new type stands higher than worn type.

High Flash Point. Oil whose vapour is only ignited at a high temperature. *See* FLASHING POINT.

Highgate Resin (*Min.*) *See* COPALINE.

High Pressure Cylinder (*Eng.*) The cylinder of a compound engine in which the steam is first expanded before passing on to the remaining cylinder or cylinders, in which the expansion is completed.

High Relief (*Sculp.*) *See* ALTO RELIEVO.

High Speed (*Eng.*) A purely relative term; applied to the linear velocity of ships, vehicles, etc., and to the rate of rotation of various motors and engines. In steam engines of the ordinary reciprocating type 400 revolutions per minute is a high speed; a small gas or petrol engine may make 1,200 to 2,000, a Parsons' steam turbine (*q.v.*) 3,000, and a small Laval turbine as many as 30,000 per minute.

High Speed Bearings (*Eng.*) Bearings whose length is four or five times their diameter are commonly used for very rapidly rotating shafts, and in many cases (especially in dynamos) the whole bearing has some slight freedom of rotation about axes at right angles to the shaft; this allows for slight errors in the alignment, or a slight amount of "give" or deformation of the shaft itself which might otherwise have serious results at high speeds.

High Warp. Tapestry in which the warp (*q.v.*) takes a vertical position, *e.g.* Gobelins tapestry. Supposed to be superior to low warp tapestry, which is manufactured with the warp in a horizontal position.

Hills, Origin of (*Geol.*) In most cases the elevated tracts known in general terms as "hills" are due either to the local piling up of materials, such as sand deposited by sea spray or drifted by the wind, or else are remnants of a mass of rock which formerly had a greater extent, but which was locally removed by some natural agent, such as running water. Hampstead and Finchley, for example, were once continuous high ground with Shooters Hill.

Himation (*Archæol.*) An outer garment worn by the ancient Greeks. It consisted of an oblong piece of cloth which covered the left shoulder, and was generally fastened over the right shoulder, leaving the right arm free.

Hip Girdle (*Zool.*) A group of bones (PELVIC GIRDLE) which give attachment to the hind limbs. The girdle is articulated to the vertebral column, and consists of the three bones, ilium, ischium, and pubis.

Hipped Roof (*Build.*) A form of roof in which the ends slope as well as the sides, there is therefore no gable.

Hippuric Acid (*Chem.*) (Benzoylglycocoll),

$$\begin{array}{l} CH_2NH\,.\,COC_6H_5 \\ | \\ COOH \end{array}$$

A white crystalline solid; melts at 187°; sparingly soluble in cold water (1 in 600); easily soluble in hot water and in alcohol. It occurs in the urine of herbiverous animals, especially of horses (hence the name); to a slight extent in human urine. When horse's urine is concentrated and hydrochloric acid added, hippuric acid separates out. It may be obtained synthetically by the action of benzoyl chloride on glycocoll in presence of caustic soda solution. On boiling the acid with strong hydrochloric acid it yields benzoic acid and glycocoll hydrochloride.

Hippurite Limestone (*Geol.*) A section of the Upper Cretaceous Rocks, mainly contemporaneous with the British Chalk. It was formed in a different zoological province from the normal Chalk, and contains the remains of a somewhat anomalous group of mollusca, whose affinities may be with the modern *Chama.* It occurs in force in the north-western part of the Mediterranean basin.

Hip Rafter (*Build.*) The angle rafter of a hipped roof. *See* ROOFS.

Hitch. (1) A check or stoppage of any kind; in particular, the stopping of a cutting tool through digging into the material. (2) In a rope, a loop, turn, or knot of a particular kind.

Hoar Frost (*Meteorol.*) When the air contains moisture and the temperature sinks below the freezing point, the particles of moisture become frozen and are deposited on leaves, trees, etc., in the form of hoar frost.

Hod (*Build.*) A three sided receptacle used for carrying bricks, mortar, or stones. Attached to it underneath is a straight handle about 4 ft. long, by which it is supported while being filled, and by means of which the hodman balances it on his shoulder when carrying the material to the workmen.

Hodograph. If lines be drawn from a fixed point, representing in magnitude and direction the velocity at successive instants of a moving body, the extremities of the lines lie on a curve termed the HODOGRAPH of the motion of the body.

Hofmann's Apparatus. *See* VAPOUR DENSITY.

Hofmann's Violet (*Chem.*) Is triethylrosaniline, a dye. Not used now. *See* ROSANILINE.

Hog Fleece, Hog Wool (*Woollen Manufac.*) The first shorn fleece of a young sheep.

Hogging (*Eng.*) The curvature of a girder, ship, or other structure, so that it is convex on the upper side; *i.e.* the central portion becomes raised relatively to the ends. *Cf.* SAGGING.

Hoist (*Eng.*) Lifting mechanism. The term is applied to a great many machines; a lift or elevator.

Holding Up (*Eng.*) Pressing a hammer, etc., against one end of a rivet while the "closing" or formation of the head is effected. The hammer is held by its handle, and the head springs away from the rivet after its inertia has been overcome by the blow of the riveter's hammer.

Holding Weft (*Textiles*). *See* WEFT.

Hollander (*Paper Manufac.*) A type of beating engine used for beating up rag pulp.

Hollands (*Linen Manufac.*) These are light plain-texture linens finished in the brown state, or dyed black, slate, etc., and highly glazed. Generally used for linings

Hollington Stone. *See* BUILDING STONES.

Hollow Column (*Eng.*) A vertical column containing a given weight of metal is much stronger if hollow than if made solid, owing to the metal being farther from the axis. *See* BEAM. Many large frames, baseplates, and other structures are made hollow for this reason.

Hollow Mandrel Lathe (*Eng.*) For small repetition work, where a number of similar objects (*e.g.* screws, etc.) are formed from a rod of metal, it is very convenient to have a lathe with a hollow mandrel. The rod of metal runs right through this mandrel, and one end projects beyond the chuck for a sufficient distance; as each object is finished it is cut off, and a fresh length of rod brought into place without loss of time in re-chucking. A hollow mandrel is often used in conjunction with a capstan head on the slide rest, which is capable of holding a variety of tools.

Hollow Roll (*Plumb.*) A lead ROLL (*q.v.*) made by bending over the edges of sheet lead, and so forming a tube.

Hollows (*Carp.*) Planes used for forming convex surfaces; the corresponding planes for forming concave surfaces are known as ROUNDS. A set of hollows and rounds used always to form part of a joiner's outfit; with them he could cut any beads or mouldings or make his own beading planes.

—— (*Patternmaking and Moulding*). The curved surface connecting two flat surfaces meeting at an interior angle; the curve adds to the strength of the casting, which would otherwise be very liable to fracture at the angle, owing to the irregular arrangement of the crystalline structure at this point.

Hollow Walls (*Hygiene*). According to a model byelaw issued by the Local Government Board as to new buildings, if the ground is to be in contact with a wall above the level of the floor of the lowest story, that wall must be made double, with a cavity $2\frac{1}{2}$ in. wide extending from the base of the wall to 6 in. above the surface of the adjoining ground; and damp proof courses (*q.v.*) must be inserted both at the base of the wall and at the level of the top of the cavity.

Hollow Ware. *See* GLASS MANUFACTURE.

Hollow Ware Presser (*Pot.*) A hollow ware presser, as distinguished from a "flat ware" presser, is a potter who makes bowls, vegetable dishes, soup tureens, and similar hollow articles which are made by the "pressing" process.

Holly. *See* WOODS.

Holmes's Signal. A tin canister containing calcium phosphide and attached to a float. To the bottom of the tin a tube is fastened, and the end is perforated so as to admit water, when the signal is to be used; at the top of the tin is a cone, the apex of which is cut off also before use. When thrown into the sea, water entering below generates spontaneously inflammable phosphoretted hydrogen, which escapes above and burns with a brilliant flame. *See* PHOSPHORETTED HYDROGEN.

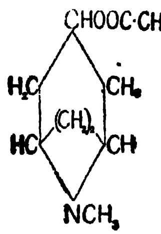
Holocrystalline Structure (*Geol.*) This occurs chiefly in eruptive rocks which have consolidated slowly and under pressure. It is confined to rocks of

either plutonic (deep seated) origin, or trappean rocks, such as dyke sand sills, which have been intruded at a lesser depth. The whole of the constituents have become crystalline; or, in other words, no trace of any ground mass is left. Granite or dolerite may be taken as typical examples. No lava is holocrystalline.

Holohedral Forms (*Min.*) Crystal forms which show the complete development of faces, *i.e.* the complete symmetry possible with a particular form.

Holtz Machine (*Elect.*) One of the first induction electrical machines of modern type; devised about 1865. It consists essentially of a fixed glass plate carrying two paper inductors and a rotating plate. The paper inductors, charged respectively + and −, act upon the rotating plate, and the repelled induced charges are received by collecting combs and led to the main terminals, where they form the working discharge. The attracted induced charges are made use of to maintain the polarity of the paper inductors, for which purpose two sector shaped windows are cut in the fixed plate, through which a tongue of the paper projects to touch the rotating disc. This type of machine requires an initial charge, and stops working when the main terminals are separated beyond the sparking distance. It is also much affected by atmospheric conditions.

Homatropine (*Chem.*)



The mandelic acid ester of tropin (*q.v.*) It is used in the form of its hydrobromide, a white crystalline solid, for dilating the pupil of the eye. Its effect does not last so long and it is not so poisonous as atropine.

Homberg's Phosphorus (*Chem.*) Fused calcium chloride. This salt, when exposed to the sun's rays for a time and then taken into a dark room, becomes phosphorescent.

Homberg's Pyrophorus (*Chem.*) A mixture of finely divided carbon, potassium sulphide, and aluminium sulphate obtained by heating alum and charcoal to redness out of contact with air. It becomes red hot on exposure to air.

Home Work (*Hygiene*). Sec. 107 of the Factory and Workshops Act, 1901, requires that lists of "outworkers" in such classes of work as may from time to time be specified by Special Order of the Secretary of State shall be kept by occupiers of factories and workshops and contractors employed by them, and shall be forwarded twice yearly, in February and August, to the District Council in which the factory or workshop is situate. Every Council shall furnish particulars as to "outworkers" employed outside their district to the Council of the district in which such workers are employed. By Sec. 108 the District Council is empowered to give notice to employers prohibiting work to be done on unwholesome premises. This section applies only to persons employed in such classes of work as the Secretary of State may specify by Special Order. Sec. 109 prohibits the making, cleansing, or repairing of wearing apparel where there is scarlet fever or smallpox. Sec. 110 prohibits home work in a house any inmate of which is suffering from a notifiable infectious disease. The work to which this section applies is the making, cleaning, washing, altering, ornamenting, finishing, and repairing of wearing apparel, and any work incidental thereto, and such other classes of work as may be specified by Special Order.

Homocentric (*Photo.*) A term employed in optics to signify that a lens is corrected for radial and tangential astigmatism of oblique pencils of light by the merging of the two focal lines into a single focal point. It is the aim of all modern anastigmatic lenses to accomplish this, in order to prevent the blurring of the image formed on the margins of the focussing screen from this defect of astigmatism.

Homogeneous. Of uniform structure throughout. In engineering, etc., a perfectly homogeneous casting or forging is much stronger than one whose internal structure is not uniform.

Homologous Series (*Chem.*) A series of organic compounds the members of which differ from each other by a multiple of CH_2. The hydrocarbons of the paraffin series form an example. Another example is the following:

$COOH\,.\,COOH$	Oxalic acid.
$COOH\,.\,CH_2\,.\,COOH$	Malonic acid.
$COOH\,.\,CH_2\,.\,CH_2\,.\,COOH$	Succinic acid.
$COOH\,.\,CH_2\,.\,CH_2\,.\,CH_2\,.\,COOH$	Glutaric acid.

Hone. A smooth grained stone used for giving a fine edge to sharp cutting tools. Hones are generally some variety of slate or similar rock.

Honey (*Botany*). The saccharine fluid secreted by glands (nectarines) in flowers. It undergoes certain changes within the stomach of the bee, and is afterwards transferred to the cells of the honeycomb.

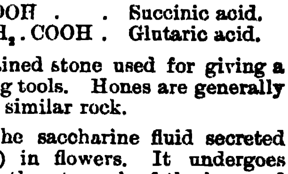
Honeycomb (*Textile Manufac.*) The term applied both to weave and fabric. It is a weave in which there is strong contrast of fast and loose interlacings, giving to the fabric a rough and honeycombed character.

Honeycombing (*Eng.*) Corrosion of boilers in the form of numerous pits or holes on the internal surface.

Honourable Ordinaries (*Her.*) The nine principal ordinaries. *See* HERALDRY *and* ORDINARIES.

Hood (*Eng.*) The funnel-like cover over a forge which leads the smoke, etc., into the chimney.

Hood Mould (*Architect.*) A projecting moulding used in Gothic work over the heads of doors and windows, following the curve of the arch. When used externally it serves the purpose of throwing off the rain; but it is also used, solely for ornament, in internal work. It is also known as a DRIPSTONE, WEATHER MOULDING, and when square in elevation as a LABEL.



HOOD MOULD.

Hooked Joint (*Carp. and Join.*) A joint in the form of a hook. Used on the meeting styles of casements and airtight cases.

Hooke's Joint (*Eng.*) A joint used to connect two lengths of rotating shafting which are not in the same straight line. Each length terminates in a horseshoe shaped fork; the ends of each fork are connected to the ends of one arm of an equal armed cross by swivel joints: if the shafts are in line, the plane of the cross is at right angles to the line of the shafts; when the shafts are not in the same straight line, the plane of the cross is inclined to either one or both shafts.

Hooke's Law (*Phys.*) Hooke discovered that if an "elastic" substance be strained or loaded in any way, then, within certain limits of load varying with the nature of the substance used, the strains produced are proportional to the loads. The law is now usually expressed in the form $\frac{\text{Stress}}{\text{Strain}} = \text{Constant}$, and this constant is known as the "Elasticity" of the substance.

Hook Up, Hook Down (*Typog.*) The end of a line which is either bracketed in the line above or that below.

Hoop Iron (*Eng.*) Thin bands of wrought iron of thickness from 20 up to 12 B.W.C. *See* WIRE GAUGES. Used for securing barrels, etc.

Hoop Iron Bond. Thin strips of iron built into walls to tie the materials together.

Hooter. A powerful steam whistle giving a deep note, used as a signal. A siren.

Hope's Experiment (*Phys.*) A well known experiment to demonstrate the existence of anomalous expansion in water near its freezing point, and also to roughly ascertain the temperature of maximum density. The apparatus consists of a tall, rather narrow cylinder containing water at the ordinary temperature, and having holes at the side for the insertion of two thermometers near the top and bottom respectively, while around the middle of the cylinder is an annular receptacle for a freezing mixture. At first the temperature of the lower thermometer falls rapidly, while the upper one is not much affected. This goes on until the lower one reaches about 4° C., then it remains stationary, and the upper one begins to fall, until at length ice may form at the top. Evidently the water becomes denser during cooling until 4° C. is reached, and then becomes less dense with further cooling.

Hopper. A funnel formed in the shape of an inverted cone or pyramid, used for feeding coal or other material in fragments into a furnace, etc.

—— (*Build.*) (1) The head of a rain water pipe. (2) A certain form of closet pan.

Hopper Feed (*Woollen Manufac.*) An automatic mechanism in which the wool is put, and then conveyed automatically on to the feed sheet of the carder. This feed is also applied to other machines, such as the scribbler.

Hops (*Botany*). *Humulus lupulus* (order, *Moraceæ*). The plant is much cultivated in the south-east of England for brewing purposes. *See* BEER.

Horizon (*Astron.*) The intersection of the celestial sphere by a plane through the eye of the observer, parallel to the surface of a liquid at rest (*i.e.* a horizontal plane).

——, **Artificial** (*Astron.*) A level reflecting surface (*e.g.* a dish full of mercury), used in finding the altitude of a star when the natural horizon is hidden.

Horizon, Geological. A term which has reference to the chronological position of any rocks which have been formed at the same period of the Earth's history, quite irrespective of their mode of origin or lithological character. Thus the desert-formed sandstones and marls of the English Trias are on the same geological horizon (or were formed contemporaneously with) certain thick beds of dolomite of marine origin in Tyrol. In like manner certain volcanic rocks in Scotland are on the same geological horizon as the limestones of Dovedale.

Horizontal Engine. Any engine whose cylinders are horizontal, but usually applied only to stationary engines.

Horizontal Force, Magnetic. The horizontal component of the magnetic force of the earth at a given place, important because it is the effective value acting upon a compass needle. Its value in London at the present time is about ·18 C.G.S. units, *i.e.* ·18 dynes per unit pole.

Horn (*Music*). *See* MUSICAL INSTRUMENTS, WIND (BRASS).

——. *See* WASTE PRODUCTS.

Hornbeam. *See* WOODS.

Hornblende (*Min.*) Silicate of iron, magnesium, aluminium, and calcium. It is one of the meta-silicates, and is now considered an aluminious variety of the species AMPHIBOLE (*q.v.*) It occurs in black monosymmetric crystals, and is an important rock forming mineral, which occurs in many gneisses, pegmatites, and eruptive rocks. It occurs along with Biotite in most of the Scottish granites and diorites, and is a common mineral in many of the andesites, porphyrites, and trachytes.

Horn Centres. Discs of horn or celluloid placed on drawings to form a point of rotation for compasses when many circles have to be drawn from the same centre; the puncturing of the paper is thus prevented and the centre maintained in its proper fixed position. The disc is usually provided with fine projecting points, which keep it in place.

Horn Lead (*Min.*) A synonym for PHOSGENITE (*q.v.*)

Horns (*Carp. and Join.*) The portion of the styles of framing projecting beyond the rails.

—— (*Eng.*) (1) In general any projecting part or point. (2) The tips or corners of the pole pieces of the field magnets of a dynamo or electric motor.

—— (*Zool.*) *See* WASTE PRODUCTS.

Horn Silver (*Min.*) Silver chloride, AgCl. Silver = 75·3, chlorine = 24·7 per cent. Cubic. More often in massive forms with a characteristic ivory lustre. It occurs, rarely, in Cornwall and in the Harz Mountain mines, but is sufficiently plentiful in South America to be a valuable ore of silver. Also in New South Wales.

Horology. *See* WATCHMAKING.

Horse (*Plast.*) The wood backing of a zinc mould, used by plasterers for running mouldings.

—— (*Plumb.*) A wooden finial, etc., forming a core which is to be covered with lead.

Horse-Brey *or* **Barnacles** (*Her.*) A kind of curb used in breaking in horses; it presses on the animal's nose. Used occasionally as a "charge."

Horse-Chestnut. *See* WOODS.

Horse-Chestnut Oil. Made from the fruit of the horse-chestnut tree. The colour of the oil is greenish brown. It may be used for burning and soap making, and is said to possess valuable medicinal qualities when used externally for gout, rheumatism, neuralgia, etc.

Horse Dung (*Foundry*). Used to give porosity to loam, from which large cores are made.

Horse Fat. Varies in colour from very light to dark yellow, according to the part of the animal it is taken from. It is used as an adulterant for lard and in soap making. The sp. gr. at 15° C. is 0·9180.

Horseflesh (*Foods*). By the Sale of Horseflesh, etc., Regulation Act, 1889, the flesh of horses, asses, and mules must not be sold or kept for sale for human food except in a shop or stall over or upon which is placed, in conspicuous and legible characters 4 in. long, an announcement that horseflesh is sold there. The following characteristics of horseflesh serve to distinguish it from beef: (*a*) The muscle fibre is much coarser. (*b*) It is darker red in colour, often has a brownish tint. (*c*) After being kept a day or two it develops a peculiar odour, and has a velvety feel to the fingers. (*d*) The fat is a deep yellow, and has a distinct odour from the first. (*e*) The ridges and tuberosities on the bones are bigger than on the bones of oxen. (*f*) Horseflesh is rich in glycogen; beef contains scarcely any. *See* FOODS.

Horse Gear. The device used for yoking horses to machinery. *See* BULLOCK GEAR.

Horsehair. Used for mixing with plaster to give increased strength, and with loam in foundry work to give porosity to cores.

Horse Power (*Eng.*) The unit of power in engineering; equal to 33,000 foot pounds of work per minute.

Hose. Flexible tubing of canvas, rubber, leather, etc., used for the conveyance of a liquid.

Hose Coupling. Metal joints used for connecting two lengths of hose. The connection may be made by a screw thread or by some form of joint or clip, which is more rapidly fastened.

Hose Pipe Tyres (*Cycles*). A colloquial expression for a single tube tyre. *See* TYRES.

Host (*Botany, Zool.*) An animal or a plant which has a parasite or commensal living upon it.

Hot Air Engine (*Eng.*) A form of motor now practically obsolete. Air is heated in some form of metal vessel, and supplied to a single acting cylinder (with piston and valves somewhat like a gas engine), in which the expansion of the air produces the motion of the piston.

Hot Metal (*Eng.*) Metal of any kind is said to be "hot" when it is at a temperature sufficiently high for some definite operation to be carried out. Thus a smith may say iron is hot when it is just at a welding or a forging heat, and not hot if below this temperature, though, of course, it is then extremely hot in the ordinary usage of the word.

Hot Plate (*Build.*) The top of a stove.

Hot Rolling (*Print.*) A process of drying and pressing by means of hot rolls.

Hot Short *or* **Red Short** (*Met.*) Iron which is brittle when hot, usually owing to the presence of sulphur.

Hot Water System (*Hygiene*). A method of warming effected by means of hot water or steam circulating in a system of closed pipes. The circulation depends upon the water being hotter, and therefore lighter, in the pipe through which it leaves the boiler than in that which brings it back. Some 12 ft. of 4 in. pipe are required per 1,000 cubic feet of air space in dwelling rooms to give a temperature of about 65°.

Hot Water Test (*Eng.*) Testing the joints of a boiler by forcing hot water in under pressure. A boiler may not leak when cold, but the expansion of its joints may make it very leaky when hot; hence the importance of this test before any attempt is made to get up steam.

Hot Waves (*Meteorol.*) Waves of exceptionally hot air which travel over countries and raise the local mean temperature to a great extent. New York, for instance, suffers from them, being so situated that the hot winds reach the city after travelling across the whole of the United States, an area which becomes greatly heated in midsummer.

Hot Well (*Eng.*) The receptacle for the hot water and condensed steam from the condenser of an engine.

Hour. *See* WEIGHTS AND MEASURES.

Hour Angle (*Astron.*) The angle which the declination circle of any celestial body makes with the meridian. It may be reckoned in degrees, but is usually expressed in time; *e.g.* if the hour angle is 21 hrs. 35 min., it is meant that 21 hrs. 35 min. have elapsed since the star crossed the meridian.

Hour Circles (*Astron.*) Great circles of the celestial sphere which pass through the poles like the meridians of the earth, and are therefore perpendicular to the celestial equator.

Household Soap. A term applied generally to all ordinary hard soaps that are used for domestic, household, or laundry purposes, and in contradistinction to toilet soaps, medicinal soaps, soft and industrial soaps (*q.v.*) *See also* MOTTLED SOAP, PRIMROSE SOAP, YELLOW SOAP, WHITE SOAP, *and* SOAP MANUFACTURE.

House Marks (*Typog.*) Corrections to be made in proofs which the piece-hand does not undertake to execute.

House Painting. This business is often carried on in connection with general building or plumbing, although this is not the case in the north of England and Scotland. The duties of the house painter include painting, paperhanging, distempering, staining, and graining; frequently sign writing, gilding, and marbling, and sometimes glass embossing are also carried on in connection with the business. Although the work of the painter is essential to the proper finish of every residence from a decorative point of view, and every other building from the point of preserving it by an application of paint, yet probably 75 per cent. of his work consists in cleaning and renovating. In painting new woodwork the constituents of the paint are varied according to the surface to which it is to be applied (*see* PAINT MIXING); but new woodwork is usually given four coats of paint. The first is called PRIMING, and is applied after the surface of the wood has been rubbed down with sandpaper, and knots have been covered with shellac dissolved in methylated spirits or naphtha (termed KNOTTING), or silver leaf, to prevent the exudation of resin. The priming coat is mixed with plenty of oil, so that it can penetrate the wood: frequently a proportion of red lead is contained in it with patent driers (*q.v.*), and it is thinned with raw linseed oil

and turpentine. After the priming coat is dry, the work is STOPPED; *i.e.* all nail holes and depressions are stopped with ordinary putty (*q.v.*) or white lead putty. The second, third, and subsequent coats are then given, ample time being allowed between each to permit of thorough drying, and the surface is then rubbed down with sandpaper, so as to render it perfectly level. The basis of the paint mostly employed is white lead, which has long remained in use because of its body (*q.v.*), or property of masking or hiding the surface to which it is applied. The poisonous nature of white lead, however, is a serious objection to it, and zinc white is rapidly growing in favour. The various earth colours (*q.v.*) or natural pigments, such as ochres, siennas, umbers, etc., are also employed to a considerable extent. If the base is white, it is usually necessary to add one or more colours to produce the required tint. *See* PAINT MIXING. After three coats of paint have been given, the woodwork is sometimes varnished, although this is usually deemed unnecessary when the paint is properly mixed. When a flat colour, or one without gloss, is required, oil in the final coat is omitted, and turpentine is employed alone to render the paint of a suitable thin consistency. Flatted work on large surfaces, such as the wall of an apartment, possesses the advantage of hiding inequalities of the surface much better than a glossy paint would. In this case the paint is usually stippled (*q.v.*) In finishing fine work, the best results are usually obtained by applying several coats in the manner described, and finishing the last one flat or without gloss, finally varnishing the whole surface. This tends to preventing blistering, while the finish is superior to that obtained in the ordinary way. In painting on plaster it is important that the surface be free from moisture; but four or five coats of paint are usually required in order to produce a satisfactory result, as the plaster is much more absorptive than wood, and increased quantity of oil and turpentine is necessary. In painting on iron, on the contrary, a smaller proportion of thinners (*q.v.*) is required. *See* IRON WORK PAINTING. DISTEMPERING is the art of painting in water colours. Distemper is made from pigments diluted with water, to which has been added some substance such as size to bind the particles of the pigments together. The pigment usually employed for distemper is whiting, which possesses considerable body when mixed with water, although very poor body when mixed with oil. The whiting is broken up in small pieces, and allowed to soak in water, and then stirred and broken up until of uniform consistency. Ordinary size melted, but not boiled, is then poured in; and if the distemper is to be coloured, the tinting colour is now added, and the whole thoroughly stirred up, and finally strained, when it is ready for use. The size must be of good quality, and only a little used, or the distemper will be apt to flake. Before the distemper is applied, it is usual to give plaster or other work a coat of clairecolle (*q.v.*) to prevent absorption. The application of distemper requires some practice to prevent laps and streaks showing and to get the surface uniform. Some colours cannot be used for distemper, as the whiting destroys them. The following is a list of the colours which may be safely employed for this work: Yellow ochre, sienna, umber, Vandyke brown, cadmium yellow, vermilion, red lead, Venetian red, Indian red, ultramarine blue, chrome green, emerald green, and all black pigments. The custom in many parts of the country in distempering a ceiling is to add a little ultramarine blue or black, in order to get rid of the yellow cast. This practice, however, is not to be recommended. If a perfectly white ceiling is required, a little blue may be added, provided that the surface of the walls is blue. In other cases the rule is to add to the white washable distemper a little of the same colour as that which prevails on the wall. This renders the surface of the ceiling apparently quite white. Of late years the use of washable distempers has increased enormously. These are distemper colours, sold ready for use or requiring only the addition of water. They are made in a large variety of colours, ranging from the most brilliant red down to pale yellows, greens, and greys, and include in their composition size, casein, or other binding material which renders them washable after they have been on the wall for some weeks. In interior decoration this class of paint is rapidly increasing in use, and a wall finished in some of the bright colours has a firm and pleasing appearance, much more satisfactory than wallpaper, and much more durable. *See also* RELIEF DECORATION, VARNISHING, MARBLING, GRAINING, PAPER HANGING, WALLPAPERS, PAINTERS' BRUSHES.

Houses Let in Lodgings. By Sec. 94 of the Public Health (London) Act, 1891, sanitary authorities are empowered to make byelaws: (*a*) for regulating the number of persons and separation of the sexes in a house or part of a house let in lodgings; (*b*) for the registration and inspection of such houses; (*c*) for drainage, cleanliness, and ventilation; (*d*) for cleansing and limewashing at stated times; (*e*) for taking precautions in case of infectious disease.

Housing (*Carp. and Join.*) A form of joint where the whole thickness of one piece is let into another piece. The ends of the treads and risers of a staircase are housed into the wall string (*q.v.*), *i.e.* the ends of these boards are fitted into grooves cut in the string.

H.P. (*Eng.*) The symbol for horse power (*q.v.*)

Hubs (*Cycle*). *See* CYCLES.

Huckaback (*Cotton Manufac.*) A standard weave for giving a rough feel and appearance to a cloth, which, however, is firmly bound. Used for towels, etc.

—— (*Linen Manufac.*) This is an old standard pattern used for towellings. It is a mixture of plain cloth and a little float, which gives the cloth a fine spot appearance with a rough surface, and makes it specially suited for the purpose for which it is intended.

Huddlestone Stone. *See* BUILDING STONE.

Hue (*Dec.*) A word used as a qualifying term in connection with colour; thus, if two crimsons are compared, one of them may be said to have a redder hue than the other. Strictly speaking, hue is the result of compounding two or more colours, which thus form hues of the particular colour which predominates. The word hue is frequently employed as a synonym for colour.

—— (*Light*). The true tint or colour of light. *See* COLOUR.

Humerus (*Zoology*). The large bone of the fore limb. It articulates with the shoulder girdle, and at the other extremity with the RADIUS and ULNA (*q.v.*)

Humetté (*Her.*) An ordinary "couped" so that it does not extend to the edge of the shield. Used chiefly of a fesse.

Humidity (*Meteorol., Phys.*) The humidity of the air is the amount of moisture which it contains.

The three terms often used in speaking of atmospheric moisture are: (1) ABSOLUTE HUMIDITY, the actual amount of water contained (in the form of vapour) in a given volume of air. (2) RELATIVE HUMIDITY, the ratio of the amount of moisture actually present to the amount necessary to cause saturation. (3) DEW POINT (*q.v.*)

Humour, Aqueous. The fluid filling the smaller anterior chamber of the eye, between the cornea and the crystalline lens.

——, Vitreous. The delicate jelly-like substance filling the larger posterior chamber of the eye, between the crystalline lens and the retina.

Hundredweight. *See* WEIGHTS AND MEASURES.

Hung (*Carp and Join.*) A term denoting that a door is fixed on hinges.

Hunter's Moon (*Astron.*) The full moon following the harvest moon (*q.v.*) rises in a manner similar to the latter; the peculiarity, however, is less noticeable than it is in the case of the harvest moon.

Hunting (*Eng.*) Variations of speed of an engine when the governor is not controlling it efficiently, *i.e.* when the governor is slowing the engine down and it goes on losing speed too long; when the governor is acting so as to increase the speed, and the speed goes on increasing beyond the proper amount. Under these circumstances the governor requires alteration.

Hunting Cog (*Eng.*) The provision of an extra tooth (the hunting cog) in a toothed wheel, so that the number of teeth on the wheel is not an exact multiple of those on the pinion. This prevents the same set of teeth from coming continually into contact, and equalises the wear.

Hurricanes (*Meteorol.*) When cyclones in the torrid zones reach their greatest development they are called by this name. These atmospheric whirls vary from a few miles to several hundred miles in diameter, and are accompanied by great violence of wind and torrential rainfall. Frequent in the West Indies.

Hyacinth (*Min.*) A transparent red variety of ZIRCON (*q.v.*), used as a gem. *See also* CINNAMON STONE.

Hyalite (*Min.*) A colourless glassy variety of Opal (*q.v.*), occurring as a mammillated incrustation.

Hydra (*Her.*) A fabulous heraldic beast. A dragon with seven heads.

Hydracrylic Acid (*Chem.*)

$$\begin{array}{l} CH_2OH \\ | \\ CH_2 \quad (\beta\text{-oxypropionic acid, or } \beta\text{-lactic acid}). \\ | \\ COOH \end{array}$$

A syrupy liquid having properties both of an acid and an alcohol: it is isomeric with lactic acid. It is obtained by boiling acrylic acid with dilute caustic soda: $CH_2 = CH - COOH + H_2O = CH_2OH.CH_2.COOH$. Also ethylene as follows:

$$\begin{array}{c} CH_2 \\ \| \\ CH_2 \end{array} \xrightarrow{HOCl} \begin{array}{c} CH_2Cl \\ | \\ CH_2OH \end{array} \xrightarrow{KOH} \begin{array}{c} CH_2 \\ | \\ CH_2 \end{array}\!\!>\!O$$

$$\xrightarrow{HCN} \begin{array}{c} CH_2OH \\ | \\ CH_2CN \end{array} \xrightarrow[\text{Acid.}]{\text{Dilute}} \begin{array}{c} CH_2OH \\ | \\ CH_2 \\ | \\ COOH. \end{array}$$

Hydramine (*Photo.*) A name given to a substance formed by mixing together hydroquinone and para-diamidobenzene, $C_6H_4(NH_2)_2$. It crystallises in thin plates which are slightly soluble in cold water, but more easily in presence of sodium sulphite, and still more so with caustic alkali. It will develop an image by itself when simply dissolved in water. Caustic lithia, however, is usually employed with it as well as sodium sulphite. The following formulæ is recommended: Hydramine, 2·16 grains; sodium sulphite, 13·4 grains; caustic lithia, 1·25 grains; water, 1 oz.

Hydrant. A stand pipe connected to a water main, and intended to afford a supply of water in case of fire.

Hydrargyrum (*Chem.*) The Latin name for mercury. From it is derived the symbol for mercury, Hg. *See* MERCURY.

Hydrastine (*Chem.*). $C_{21}H_{21}NO_6$. A well crystallised (rhombic prisms) alkaloid, occurring along with berberine in *Hydrastis canadensis*. Melts at 132°. It is lævorotatory in chloroform solution. When administered it contracts the blood vessels. It is the active principle in the alcoholic extract of the hydrastis root used in medicine. The constitution of this alkaloid is known, but is too complex to be given here; it is an isoquinoline derivative.

Hydrated (*Chem., Min., etc.*) Combined with (or in some cases mixed with) water.

Hydraulic Accumulator (*Eng.*) A reservoir in the form of a large vertical cylinder. furnished with a heavily loaded piston. Water forced into the vessel by means of powerful pumps is maintained at a constant pressure, which is determined by the amount of load on the piston.

Hydraulic Belt (*Eng.*) A belt of some porous material, driven at a very high speed, with one part dipping into water. The belt "licks up" the water, and a layer of water adheres to the belt and can be raised to a high level, thus serving as a pump which has no valves or passages liable to be choked up by impurities.

Hydraulic Crane (*Eng.*) A crane in which the chain is moved by a hydraulic press or ram. The powerful short stroke of the ram is converted into a long movement of the chain by an arrangement of pulley blocks.

Hydraulic Leather. A CUP LEATHER. *See* HYDRAULIC PRESS.

Hydraulic Lime (*Build.*) Lime that is capable of setting under water. *See* CEMENTS.

Hydraulic Limestone (*Geol.*) Any limestone whose composition fits it for the manufacture of a cement which will set under water. *See also* CEMENTS.

Hydraulic Machinery (*Eng.*) A term applied to presses, rams, etc., which are worked by water forced in under pressure. The pressure is maintained by a reservoir at a high level, or a hydraulic accumulator (*q.v.*), into which the water is forced by a pump worked by an engine.

Hydraulic Main (*Gas Manufac.*) *See* GAS MANUFACTURE.

Hydraulic Mean Depth. The hydraulic mean depth of a pipe of any shape equals the sectional area of the current of fluid divided by the wetted perimeter. In circular pipes it is always one-fourth of the diameter; in pipes of oval or elliptical

section, such as egg-shaped sewers, it varies according to the level of the liquid flowing in them.

Hydraulic Motor (*Eng.*) A small engine driven by water under pressure. It may be either of the reciprocating type, with cylinder and piston, or some form of turbine (*q.v.*)

Hydraulic Press *or* **Ram.** Most hydraulic machinery depends for its motion upon a cylinder which is of one well marked type, shown in the illustration (fig. 1). A heavy casting A forms the cylinder, bored out at B to make a smooth fit with the RAM or piston C. This piston carries the HEAD D, which possesses a broad flat surface if used for raising weights or for compressing any material. At E the cylinder has a channel bored out in the metal, and this channel contains the CUP LEATHER shown in section in fig. 2. The water forces this leather into close contact with the inside of the channel E and the ram C, thus making a watertight joint. Water enters at F, being forced in by a pump, or from a reservoir or accumulator, in which it is stored under pressure.

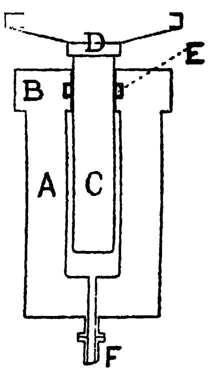


Fig. 1.

If the ram is required for working a crane, the head D is replaced by a set of pulley blocks, over which runs a chain so arranged as to multiply the motion of the ram to any extent required. For example, the motion may be multiplied four times, so that if the ram move 1 ft. the end of the chain moves 4 ft. The head D may carry dies used in shaping metal, either cold or hot, thus forming a HYDRAULIC FORGING PRESS. It may be connected directly to a lift, forming a HYDRAULIC LIFT, in which case the cylinder is elongated so as to have a length of stroke equal to the height of the lift, or else the lift may be raised by tackle similar to that of the hydraulic crane. This arrangement is often termed a HYDRAULIC HOIST. A small press for raising weights is termed a HYDRAULIC JACK, and is often portable, being driven by a hand pump. The tubing F is usually a thick walled pipe of iron or steel, often called HYDRAULIC TUBE, even when used for other purposes.

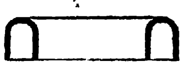


Fig. 2.

Hydraulics (*Eng.*) The science dealing with liquids in motion, in connection with their useful application, as distinguished from hydrodynamics (*q.v.*)

Hydrazine (*Chem.*), $H_2N.NH_2$ (Diamide). Probably a gas; best known as the hydrate $N_2H_4.H_2O$, a colourless, fuming liquid. Boils at 118° at 739 mm. When heated the hydrate attacks glass, and destroys cork and rubber. Powerful reducing agent; strong diacid base. Prepared from aminoguanidine, $HN=C\langle^{NH.NH_2}_{NH_2}$ (*see* GUANIDINE), by boiling with strong caustic soda solution, and adding sulphuric acid to cooled solution to obtain hydrazine sulphate. The latter compound is distilled with caustic potash solution in silver retort with silver condenser.

Hydrazines (*Chem.*) Substitution products of hydrazine, but they are not formed as a rule directly from hydrazine; *e.g.* hydrazobenzene (*q.v.*) is symmetrical diphenylhydrazine. *See also* PHENYLHYDRAZINE.

Hydrazobenzene (*Chem.*), $C_6H_5NH.NH.C_6H_5$. Colourless leaves; melts at 131°; camphorlike smell; oxidised in moist air to azobenze; insoluble in water; soluble in alcohol and in ether. Strong acids convert it into benzidine (*q.v.*) On reduction it yields aniline. It may be prepared by reduction of nitrobenzene (*a*) by zinc dust and caustic soda solution; (*b*) by electrolysis, using copper cathode and lead anode, the former being immersed in an alcoholic solution of nitrobenzene containing a little sodium acetate, and the latter in a porous pot containing strong sodium carbonate solution.

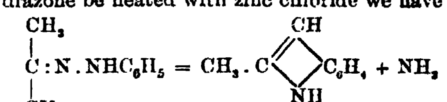
Hydrazoic Acid (*Chem.*) AZOIMIDE (*q.v.*)

Hydrazones (*Chem.*) Compounds formed from organic substances of various classes which contain the carboxyl group $(-CO-)$ by union with phenylhydrazine and elimination of water. Thus aldehydes and ketones of every kind form hydrazones, and their formation is used in deciding whether a substance is an aldehyde or a ketone. Examples of the formation of hydrazones are:

$$\begin{array}{l} CH_3 \\ | \\ CO \end{array} + \underset{\text{Phenylhydrazine.}}{H_2N.NHC_6H_5} = \underset{\text{Aldehyde Hydrazone.}}{\begin{array}{l} CH_3 \\ | \\ C:N.NHC_6H_5 \\ | \\ H \end{array}} + H_2O$$

$$\begin{array}{l} CH_3 \\ | \\ CO \\ | \\ CH_3 \end{array} + H_2N.NHC_6H_5 = \underset{\text{Acetone Hydrazone.}}{\begin{array}{l} CH_3 \\ | \\ C:N.NHC_6H_5 \\ | \\ CH_3 \end{array}} + H_2O$$

These two hydrazones are crystalline solids. The hydrazones revert to their constituents when heated with dilute acids. They readily form heterocyclic compounds with loss of ammonia; then if acetone hydrazone be heated with zinc chloride we have:



a-Methyl Indole.

For another example of a hydrazone *see* ETHYL ACETOACETATE. The dihydrazones are called osazones (*q.v.*)

Hydrides (*Chem.*) Compounds of two elements, one of which is hydrogen. The non-metallic hydrides are gases or liquids, *e.g.* H_2O, HCl, NH_3; the metallic hydrides are solids, usually unstable.

Hydriodic Acid, Hydrogen Iodide (*Chem.*), HI. A colourless gas; pungent odour; liquefies at 0° under a pressure of 4 atmospheres; solidifies at −55°. The gas is 4·4 times heavier than air: much more readily decomposed by heat than either hydrochloric or hydrobromic acids. It is also decomposed by sunlight. It is very soluble in water, the solution forming a strong acid, and, unlike the two acids just mentioned, it dissolves silver. The solution is decomposed by sulphuric acid thus:

$$2HI + H_2SO_4 = I_2 + 2H_2O + SO_2.$$

The strong solution is much used as a reducing agent in organic chemistry. Thus it reduces iodoform to methylene iodide, $CHI_3 + HI = CH_2I_2 + I_2$, and tartaric acid to malic acid, and then to succinic acid (*q.v.*) The acid is prepared by precisely similar methods to hydrobromic acid (*q.v.*) Its salts are called iodides (inorganic) or hydriodides (organic).

Hydrobromic Acid, Hydrogen Bromide (*Chem.*), HBr. A colourless gas; irritating smell; fumes in air; liquefies at $-69°$. Very soluble in water, forming the ordinary hydrobromic acid solution, which has similar properties to hydrochloric acid, but is decomposed by *strong* sulphuric acid.

$$H_2SO_4 + 2HBr = 2H_2O + SO_2 + Br_2.$$

It may be obtained by passing hydrogen and bromine vapour over heated platinum; by action of sulphur dioxide upon bromine in water (reverse of equation given above); by dropping bromine into mixture of water and amorphous phosphorus, and passing the gas evolved over moist amorphous phosphorus to remove bromine vapour.

$$P + 5Br + 4H_2O = 5HBr + H_3PO_4.$$

Hydrocarbons. Compounds of carbon and hydrogen. The possible number of these compounds is infinite; the known number is very large. To understand how it is that carbon can form an unlimited number of compounds with hydrogen, it must be remembered that the carbon atom is tetravalent, that is, it has the power of combining with four atoms of hydrogen or three atoms of hydrogen and one other atom or group equivalent in combining value to one atom of hydrogen, and so on; that carbon atoms have a unique power of combining with one another, and that they can do this in three different ways, *viz.* two atoms can combine together with one combining unit of each, giving what is called the *single linking*, or with two combining units of each giving the *double linking*, or with three combining units of each giving the *treble linking*. The following classes of hydrocarbons exist:—(1) OPEN CHAIN HYDROCARBONS: (*a*) Saturated, (*b*) Unsaturated. (2) CLOSED CHAIN HYDROCARBONS *or* CYCLIC HYDROCARBONS. In the first class the carbon atoms are so united that they do not form a closed figure or ring. The saturated hydrocarbons of this class are called paraffins (*q.v.*); they may all be regarded as derived from the first member, methane, CH_4. Suppose two hydrogen atoms are removed, one from each of two molecules of methane, and the residues united, we get the next member, ethane, C_2H_6,

$$CH_3 + CH_3 \qquad CH_3 - CH_3.$$
$$H \qquad H$$

This process can be repeated indefinitely. The member next to ethane is propane, C_3H_8. If it is written $CH_3 . CH_2 . CH_3$, we see that two different hydrocarbons will result, according as we now replace a terminal hydrogen atom by CH_3 or a central hydrogen by CH_3, thus:

$$CH_3 . CH_2 . CH_2 . CH_3 \qquad \begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!\Big\rangle CH . CH_3.$$

The compounds so produced are different, but both have the formula C_4H_{10}. The first is called butane, and the second isobutane. As we pass up the series the number of hydrocarbons having the same empirical formula, but different constitutional formulæ increase very rapidly. There are 802 hydrocarbons of the formula $C_{13}H_{28}$. These hydrocarbons are called saturated, because every carbon atom is united to its maximum number of hydrogen atoms, and the carbon atoms are "singly linked" together. If from two molecules of methane we take away from each two hydrogen atoms and unite the residues thus:

$$\begin{matrix} H_2 & CH_2 & CH_2 \\ H_2 & CH_2 & CH_2 \end{matrix}$$

we have the unsaturated hydrocarbon ethylene, C_2H_4. It is called unsaturated because each carbon atom has the power to unite with one hydrogen atom to form the saturated hydrocarbon ethane; also its carbon atoms are said to be "doubly linked." A series of hydrocarbons can be derived from ethylene by the same procedure as the paraffins are derived from methane: they are called olefines (*q.v.*) In a precisely similar way the acetylenes (*q.v.*) arise. The closed chain hydrocarbons have their carbon atoms joined in such a way as to form a closed figure or ring. In the hydrocarbon hexane, $CH_3 . CH_2 . CH_2 . CH_2 . CH_2 . CH_3$, if one hydrogen atom be removed from each terminal carbon atom these will unite, and the six carbon atoms form a ring,

$$\begin{matrix} & CH_2 & \\ & & CH_2 \\ H_2C & & CH_2 \\ & CH_2 & \end{matrix}$$

hexamethylene (*q.v.*) This compound is a derivative of benzene (*q.v.*), in which the carbon atoms are known to be united in a ring. The number of these cyclic hydrocarbons is very large. For examples, *see* TRIMETHYLENE, BENZENE, NAPHTHALENE, ANTHRACENE. For simplicity we have spoken in what has gone before of the removal of hydrogen atoms; in fact, this is done indirectly. Halogens are first introduced, generally bromine or iodine, and these removed by sodium or other appropriate reagents. *See* PARAFFINS, OLEFINES, ACETYLENES, *and also* FOODS.

Hydrocarbons, Native (*Geol.*) A general term applied to coal, lignite, brown coal, oil shale, and other carbonaceous deposits of sedimentary origin, as well as to any of a large series of hydrocarbon compounds of somewhat more definite chemical composition, which occur in the mineral state. Amongst these may be instanced amber, petroleum, asphaltum, elastic bitumen, jet, etc.

Hydrochloric Acid (*Chem.*), HCl. Also termed HYDROGEN CHLORIDE, SPIRITS OF SALT, MURIATIC ACID. A colourless gas with keen acid smell; liquefies under a pressure of 40 atmospheres at 10°; solidifies at $-115°$. The dry gas and the liquid are, chemically speaking, very inactive—do not redden litmus nor attack metals. The gas is very soluble in water: at 0° and 760 mm. 1 volume of water dissolves 503 volumes of hydrogen chloride, or under the same conditions 1 gram of water dissolves ·825 grs. of the gas. The moist gas or its solution in water behaves as a strong acid. *See* ACID. The gas is partly decomposed (dissociated) above 1500°; when not perfectly dry, it is decomposed by sodium, giving half its volume of hydrogen. To obtain it on the large scale common salt is heated with sulphuric acid. *See under* ALKALI. In the laboratory it is prepared by heating common salt with sulphuric acid in a glass flask, and passing the gas evolved through a small quantity of water to wash it, $NaCl + H_2SO_4 = NaHSO_4 + HCl$. The gas can be dried by passing it over calcium chloride or through concentrated sulphuric acid. It is also produced when any chloride (except silver chloride and mercuric chloride) is heated with sulphuric acid; when chlorine acts upon hydrocarbons, forming substitution

products, *e.g.* $CH_4 + Cl_2 = CH_3Cl + HCl$; and when hydrogen and chlorine (not absolutely dry) are mixed together in equal volumes and exposed to a bright light. In the latter case, if the illumination is momentary only, a sudden expansion occurs, and the mixture recovers its original volume ("Draper effect"), only a trace of hydrogen chloride being formed. Its salts are called chlorides in inorganic chemistry; hydrochlorides in organic chemistry.

Hydrocyanic Acid, Prussic Acid (*Chem.*), HCN. Colourless liquid, said to have smell of almonds; but people differ enormously in their sensibility to the smell. Boils at 26°; solidifies at −15°; one of the most poisonous substances known; burns with violet flame; mixable with water in all proportions, contraction occurring. On keeping, the dilute acid undergoes hydrolysis (*q.v.*), forming ammonium formate and other substances:

$$HCN + 2H_2O = HCOONH_4.$$

It occurs as a product of hydrolysis of the glucoside amygdalin (*q.v.*) Oil of bitter almonds prepared from this substance may contain in a crude state up to 15 per cent. of the acid. The acid is prepared by distilling potassium ferrocyanide with dilute sulphuric acid:

$$2K_4Fe(CN)_6 + 3H_2SO_4 = K_2Fe \,.\, Fe(CN)_6 + 6HCN.$$

If the acid is required anhydrous it can be dried over calcium chloride. The British Pharmacopœia acid is 2 per cent. hydrocyanic acid. The salts are called CYANIDES.

Hydrodynamics. The purely theoretical science dealing with the motion of fluids.

Hydroferricyanic Acid (*Chem.*), $H_3Fe(CN)_6$. Shining brownish green needles; soluble in water and in alcohol; insoluble in ether; it is unstable. Obtained by adding sulphuric acid to lead ferricyanides, or by adding concentrated hydrochloric acid to a cold saturated solution of potassium ferricyanide. It is doubtful if the pure acid has been obtained. Its salts are called FERRICYANIDES.

Hydroferrocyanic Acid (*Chem.*), $H_4Fe(CN)_6$. White pearly leaflets; soluble in water and in alcohol; insoluble in ether. It is a strong tetrabasic acid; decomposes on heating to 400° C. into hydrocyanic acid and the compound $H \,.\, Fe(CN)_5$. It is obtained by saturating a concentrated solution of potassium ferrocyanide with ether, and adding excess of hydrochloric acid. The precipitate obtained is repeatedly dissolved in water and precipitated by ether. Its salts are called FERROCYANIDES.

Hydrofluoric Acid (*Chem.*), HF. A colourless liquid; boils at 19·5°; fumes in air. The fumes are very dangerous if inhaled: the liquid causes sores if dropped on the skin. It does not attack glass if perfectly anhydrous; but the presence of a trace of water causes it to do so with great avidity. On this account the strong acid is kept in platinum vessels; the dilute acid can be kept in guttapercha bottles. The action upon glass is as follows: The silica gives silicon tetrafluoride (a gas); the sodium and calcium are converted into fluorides.

$$SiO_2 + 4HF = SiF_4 + 2H_2O$$
$$Na_2O + 2HF = 2NaF + H_2O$$
$$CaO + 2HF = CaF_2 + H_2O$$

The vapour density of the acid is two and a half times the normal, just above the boiling point, but becomes normal at 90°. The anhydrous acid is prepared by heating the acid potassium fluoride (HF . KF) in a platinum retort with a condenser and receiver of the same metal, a freezing mixture being used to condense the acid. The dilute acid is obtained by heating calcium fluoride (fluorspar) with sulphuric acid in a lead apparatus. The acid is used for etching on glass. The salts of hydrofluoric acid are called FLUORIDES; most metallic fluorides are soluble in water; only those of the alkaline earths are insoluble, and are obtained by dissolving the carbonate in hydrofluoric acid, or, in case of the insoluble fluorides, by precipitating a soluble salt of the metal with a soluble fluoride. Calcium fluoride is insoluble in water, while the other halogen calcium salts are very soluble. Silver fluoride is soluble, while the other halogen silver salts are insoluble.

Hydrofluosilicic Acid (*Chem.*), H_2SiF_6. Only known in solution; the strong solution fumes in air. It is prepared by dissolving silica in hydrofluoric acid or by passing the gas silicon tetrafluoride into water and filtering from the gelatinous silicic acid formed at the same time, $SiF_4 + 4H_2O = H_2SiF_6 + H_4SiO_4$. It is occasionally used as a test for potassium and for barium, as solutions of the salts of these metals give colourless precipitates with hydrofluosilicic acid; *viz.* K_2SiF_6, potassium silicofluoride and $BaSiF_6$, barium silicofluoride. Potassium silicofluoride is used in the preparation of SILICON (*q.v.*)

Hydrogen (*Chem.*), H. Atomic weight, 1. A colourless odourless gas; the lightest substance known; very slightly soluble in water; when liquefied the liquid boils at −253° C., and the solid melts at −257° C.; the specific heat of the solid (obtained by calculation from latent heat of evaporation) is about 6, which is higher than that of any known substance. It readily unites with oxygen to form water, and the union is accompanied by evolution of much heat. Thus when a mixture of 2 volumes of hydrogen and 1 volume of oxygen is burned, we have the intensely hot oxyhydrogen flame; when hydrogen burns in air the flame is not so hot on account of the diluting action of the atmospheric nitrogen. Hydrogen combines readily with chlorine to form hydrogen chloride—another reaction which gives rise to much heat. Neither of these actions takes place if the gases are absolutely dry. On account of these reactions hydrogen is called a strong reducing agent. *See* REDUCTION. Thus, when passed over certain metallic oxides heated to redness, it unites with their oxygen, and the metal is set free; *e.g.* CuO, PbO, HgO. When passed over heated ferric chloride, it gives ferrous chloride and hydrochloric acid gas, $FeCl_3 + H = FeCl_2 + HCl$; or if zinc and hydrochloric acid are added to a solution of ferric chloride, the hydrogen which would be set free from the zinc and hydrochloric acid removes chlorine from the ferric chloride, producing ferrous chloride. This is an example of the use of NASCENT HYDROGEN; the hydrogen in this case reacts when it is in the ionic (*see* IONS) condition, that is before the hydrogen atoms have had time to form the stable hydrogen molecule. Hydrogen occurs to a minute extent free in the atmosphere, in a state of combination in water (⅑ part by weight), in all acids, and in all naturally occurring organic substances. It may be obtained: (1) By decomposition of water acidified with sulphuric acid by a current of electricity. (2) From water by the action of metals such as sodium, potassium, or calcium, which decompose water at the ordinary temperature, $2K + H_2O = 2KOH + H_2$, or by passing steam over iron, magne-

sium, and certain other metals heated to redness, $Mg + H_2O = MgO + H_2$. (3) By the action of acids (except nitric acid) on some of the commoner metals, such as zinc, iron, tin (not copper or lead), $Zn + 2HCl = ZnCl_2 + H_2$. (4) By heating aluminium or zinc with caustic soda solution. Hydrogen is used in filling balloons and airships, and in the oxyhydrogen flame. *See* OXYHYDROGEN FLAME *and* LIGHT. Acids are often called hydrogen salts; *e.g.* nitric acid is sometimes called hydrogen nitrate; sulphuric acid, hydrogen sulphate; and so on.

Hydrogen Chloride (*Chem.*) This name is generally used for hydrochloric acid gas. *See* HYDROCHLORIC ACID.

Hydrogen Dioxide (*Chem.*) HYDROGEN PEROXIDE (*q.v.*)

Hydrogen Disodium Phosphate (*Chem.*) The common phosphate of sodium. *See under* SODIUM COMPOUNDS.

Hydrogenium (*Chem.*) When palladium is heated in hydrogen it absorbs 930 times its own volume of the gas, and increases about 10 per cent. in volume. The name hydrogenium has been given to this absorbed hydrogen. The specific gravity of hydrogenium has been calculated to be ·62; this value is eight times that of liquid hydrogen.

Hydrogen Monoxide (*Chem.*) WATER (*q.v.*)

Hydrogen Nitrate (*Chem.*) NITRIC ACID (*q.v.*)

Hydrogen Peroxide, Hydrogen Dioxide (*Chem.*), H_2O_2. A colourless liquid; when pure it is about half as heavy again as water; it freezes at a very low temperature. The pure substance easily decomposes into water and oxygen; on complete decomposition it yields about 500 times its own volume of oxygen. Hydrogen peroxide is usually sold in two strengths, "20 volume" and "10 volume," meaning hydrogen peroxide of such strength that the first gives 20 times its own volume of oxygen when heated, and the second 10 times its volume. Hydrogen peroxide is soluble in ether. On account of the ease with which this substance yields oxygen, it is a powerful oxidising agent (*see* OXIDATION): thus it converts metals such as iron and magnesium into the hydroxides; it oxidises many lower oxides to higher oxides, as sulphur dioxide to sulphuric acid, arsenious oxide to arsenic acid, the action in the case of metallic oxides taking place in alkaline solution; it oxidises lead sulphide (black) to lead sulphate (white), hence its use in restoring oil paintings; it oxidises many organic substances, hence its use in bleaching hair, silk, ivory, etc., and as a dentrifice. With ozone and silver oxide a reduction occurs:

$$H_2O_2 + O_3 = H_2O + 2O_2;$$
$$Ag_2O + H_2O_2 = H_2O + 2Ag + O_2.$$

A number of finely divided and dry solids resolve hydrogen peroxide into water and oxygen without apparent change themselves; such are carbon, platinum, manganese dioxide. Hydrogen peroxide occurs in small quantity in the atmosphere. It is formed when a burning jet of hydrogen is allowed to impinge on a surface of ice cold water. It is usually prepared by adding barium peroxide gradually to cold dilute sulphuric acid, always keeping the latter in excess; the excess of acid can be removed by baryta water. The insoluble barium sulphate is filtered off, and the peroxide concentrated over sulphuric acid under reduced pressure. *See also* SODIUM DIOXIDE. The two best tests for hydrogen peroxide are: (1) It liberates iodine from potassium iodide, $H_2O_2 + 2KI = 2KOH + I_2$. (2) On adding chromic acid and then ether, the ether is coloured blue.

Hydrogen Phosphide. Another term for phosphoretted hydrogen. *See under* PHOSPHORUS COMPOUNDS.

Hydrogen Sulphate (*Chem.*) Another name for SULPHURIC ACID (*q.v.*)

Hydrogen Sulphide (*Chem.*) Another name for sulphuretted hydrogen. *See under* SULPHUR COMPOUNDS.

Hydrolysis (*Chem.*) The resolution of certain classes of organic compounds, such as esters, amides, and nitriles, into two simpler compounds by the fixation of the elements of water. When ethylacetate, for example, is boiled with water it yields alcohol and acetic acid, and the change may be supposed to take place thus:

$$\begin{array}{c} CH_3 \\ | \\ CO \\ | \\ OC_2H_5 \end{array} + HOH = \begin{array}{c} CH_3 \\ | \\ C \begin{array}{l} \diagup OH \\ \diagdown OH \end{array} \\ | \\ OC_2H_5 \end{array} = \begin{array}{c} CH_3 \\ | \\ C \begin{array}{l} \diagup OH \\ \diagdown\!\diagdown O \end{array} \end{array} + C_2H_5OH.$$

Similarly acetamide gives acetic acid and ammonia:

$$\begin{array}{c} CH_3 \\ | \\ CO \\ | \\ NH_2 \end{array} + HOH = \begin{array}{c} CH_3 \\ | \\ C \begin{array}{l} \diagup OH \\ \diagdown OH \end{array} \\ | \\ NH_2 \end{array} = \begin{array}{c} CH_3 \\ | \\ C \begin{array}{l} \diagup OH \\ \diagdown\!\diagdown O \end{array} \end{array} + NH_3.$$

The rate of hydrolysis is greatly accelerated by the presence of an alkali such as caustic soda, or an acid such as hydrochloric. In the case of ethylacetate the caustic soda would neutralise the acetic acid and thus prevent any reverse reaction; in the case of acetamide an acid would neutralise the ammonia.

Hydrometer (*Phys.*) An instrument for directly measuring the specific gravity of liquids. It consists of a graduated glass tube made to float vertically in the liquid by means of a hollow bulb below, suitably weighted with shot or mercury. The graduations are usually on a paper scale inside the sealed tube. Evidently the instrument will sink in any liquid until it displaces a volume of liquid equal to itself in weight; *i.e.* in a dense liquid it will sink to a smaller depth than in a less dense one. In order to avoid inconvenient lengths of stem, it is usual to employ distinct instruments (or a range of instruments) for liquids denser and less dense than water respectively. The earlier instruments of the kind were graduated in such a way that a calculation was required to give the specific gravity. *See* HYDROMETER SCALES. Now they are usually made direct reading, and are very useful for rapid determination when sufficient liquid is available and great accuracy is not essential.

——, Nicholson's. This instrument is of more interest theoretically than practically, and is really more suitable for taking the specific gravities of solids than for liquids. Its advantage is that it can be applied to either purpose. It is usually a brass cylindrical float, carrying scale pans above and below, the upper one being attached to the float by a narrow stem on which is a single fixed mark, and the whole weighted to float vertically. In use the instrument is floated in water, and weights placed in the upper scale pan until the fixed mark is level with the water surface; then it is placed in the liquid in question, and weights added or subtracted until the fixed mark

is again at the liquid level. Let W = weight of instrument, W_1 = weight required to sink it to fixed mark in water, and W_2 = weight required for the same purpose in the liquid;

$$\text{then } W + W_1 = \text{weight of water displaced}$$
$$W + W_2 = \quad ,, \quad ,, \text{ liquid displaced}$$

and the volume in each case is the same.

$$\therefore \text{ S.G. of the liquid} = \frac{W + W_2}{W + W_1}$$

In the case of a solid insoluble in water, a piece of it is placed in the upper pan, and weights removed until the fixed mark is level with the water surface. Then if W_3 be weight now in scale pan, the weight of the solid is $W_1 - W_3$. The solid is then placed in the lower pan, and weights added to upper pan until level is same as before. Let W_4 be weight now in scale pan, then weight of water displaced by solid is $W_4 - W_3$;

$$\text{hence S.G. of the solid is } \frac{W_1 - W_3}{W_4 - W_3}$$

Hydrometer Scales. These may be graduated to read off the specific gravity directly, *e.g.* in water the level of the liquid is opposite to the point marked 1 on the scale. In a liquid whose specific gravity is ·995 the level of the liquid is opposite to the graduation marked ·995, and so on. In many cases, however, water is taken as 1,000, and the reading in the case quoted then becomes 995. Several arbitrary scales are in use in various trades, *e.g.* those of BAUMÉ, BECK, CARTIER, and TWADDELL. To obtain the actual density of a liquid from the reading on any one of these scales, the following formulæ may be used; in each case the reading (in scale divisions or hydrometer degrees) is denoted by x.

Baumé's Scale (lighter than water) density $= \dfrac{144}{144 + x}$

(heavier ") $= \dfrac{144}{144 - x}$

Cartier's Scale $= \dfrac{136{\cdot}8}{126{\cdot}1 + x}$

Beck's Scale $= \dfrac{170}{170 \pm x}$

Twaddell's Scale ... $= \dfrac{100 + \frac{x}{2}}{100}$

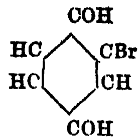
Thus let the density of a liquid be 30° Twaddell, then the actual value of the specific gravity is

$$\frac{100 + \frac{30}{2}}{100} = 1{\cdot}15.$$

Hydroquinone or Paradioxy Benzene (*Chem.*), $C_6H_4(OH)_2$; also called QUINOL. A white crystalline solid; melts at 169°; easily soluble in water, alcohol, or ether. It is a reducing agent, being oxidised to quinone. It occurs combined with glucose in the glucoside arbutin in the bearberry. It is obtained by reduction of quinone (*q.v.*) by sulphurous acid. *See* FOLLOWING.

—— (*Photo.*) This substance was first introduced as a developer for gelatine plates by Captain (now Sir William) Abney in 1880. It works well without the addition of bromide, giving negatives beautifully clean and of good colour. It has a tendency to give contrast, and for this reason is valuable in cases of over exposure.

Hydroquinone Br (*Photo.*) This is hydroquinone in which one atom of hydrogen has been replaced by bromine:



$(C_6H_2(OH)_2Br)$

It is said to produce softer negatives than hydroquinone itself.

Hydrostatics. The theory dealing with the forces exerted by or on fluids at rest.

Hydrothermal Action (*Geol.*) The chemical action set up in connection with rock masses below the surface by waters acting at temperatures and pressures which may often be sufficiently high to bring about solution of the rocks affected, and thus lead to their reconstruction in a crystalline form. In the cases in which alkaline matters are present in the thermal waters, hydrothermal action may give rise to the first stages in the formation of eruptive rocks.

Hydroxide (*Chem.*) A compound containing the hydroxyl group OH. Hydroxides may be acid or alkaline in character. The metallic hydroxides, such as those of potassium, sodium, calcium, etc., KOH, $NaOH$, $Ca(OH)_2$, are powerful alkalis; those of iron, aluminium, zinc, etc., $Fe(OH)_3$, $Al(OH)_3$, $Zn(OH)_2$, are basic in character. The non-metallic hydroxides are acids, such as boric acid, $B(OH)_3$; silicic acid, $Si(OH)_4$; sulphuric acid, $SO_2(OH)_2$, etc. In organic chemistry the basic hydroxides of inorganic chemistry are represented by the alcohols and quaternary ammonium bases, *e.g.* C_2H_5OH and $N(C_2H_5)_4OH$, the former acting as weak bases and the latter as powerful alkalis. The acid hydroxides are represented by the carboxylic acids, *e.g.* CH_3COOH, which is acetic acid. In organic nomenclature the name hydroxyl for the OH group is often shortened to "oxy"; thus glycollic acid, $CH_2OH.COOH$, is often called oxyacetic acid.

Hydroxy (*Chem.*) A prefix applied to denote the presence of the hydroxyl group (–OH) in a compound. The word is often shortened to "oxy." Thus tartaric acid is sometimes called dihydroxysuccinic or dioxysuccinic acid.

CH_2COOH	CHOHCOOH
|	|
CH_2COOH	CHOHCOOH
Succinic Acid.	Tartaric Acid.

Hydroxyl (*Chem.*) The name given to the group –OH. *See under* HYDROXIDE.

Hydroxylamine (*Chem.*), NH_2OH. A white crystalline solid; melts at 33°; boils at 5·8° under a pressure of 22 mm. of mercury; its vapour explodes at above 100°; deliquesces and decomposes on exposure to air; soluble in water, less soluble in alcohol, still less in ether. It is a powerful base, forming crystalline salts with acids. Oxidising agents set it on fire. Nitrous acid yields with it hyponitrous acid, which decomposes into nitrous oxide and water:

$$HO.NH_2 + ON.OH = HON:NOH + H_2O = N_2O + 2H_2O.$$

It is an extremely important reagent in organic chemistry; for information on this point *see* OXIMES. It may be prepared from hydroxylamine hydrochloride by dissolving the latter in methyl alcohol, adding sodium methoxide (CH_3ONa), filtering off the

precipitated common salt, and fractionally distilling the filtrate till a solid distillate is obtained. The hydrochloride is prepared best by mixing concentrated solutions of sodium nitrite (1 mol.) and sodium hydrogen sulphite (2 mols.), adding potassium chloride and allowing to stand, boiling the precipitate which forms for several hours with water. On cooling, potassium sulphate separates first; then hydroxylamine sulphate. The latter is purified by recrystallisation. From it the hydrochloride is obtained by addition of barium chloride, and after filtering off the barium sulphate, crystallising the solution of hydrochloride.

Hygrometer (*Phys.*) An instrument for measuring the amount of aqueous vapour in the air, or more frequently what is known as its HYGROMETRIC STATE (*q.v.*) The direct chemical method of separating a known volume of air through a series of drying tubes, and thus finding the amount of vapour present by the increase in weight, is seldom used on account of its slow and laborious nature, although it is very accurate. Most hygrometers, such as those of Daniell, Regnault, and Dines, are really instruments for finding the dewpoint, and depend upon cooling some surface in the open air until moisture is deposited upon it. An exception is the WET AND DRY BULB HYGROMETER, which depends upon the cooling produced by evaporation. The readings have to be reduced by the use of an empirical formula or tables.

——, **Daniell's.** One of the oldest forms of dewpoint hygrometers, now little used. It is practically a cryophorus, containing ether instead of water; *i.e.* a bent tube connecting two bulbs partly filled with ether and sealed up during boiling to expel air. One bulb is of black glass, and contains a delicate thermometer, and the other is covered with a muslin rag. In use the ether is collected in the blackened bulb, and the rag on the other bulb moistened with ether, the evaporation of which condenses the vapour within, and thus sets up rapid evaporation of the liquid in the blackened bulb, with a consequent fall of temperature. The temperature at which dew forms on the cooled bulb is noted, and also the temperature at which it disappears when evaporation ceases, the mean of the two being taken to be the dewpoint. This form of instrument is affected by many sources of error, and is practically obsolete.

——, **Regnault's.** One of the most accurate forms of dewpoint hygrometer, essentially consisting of a glass tube ending in a thin polished silver thimble, fitted with a stopper carrying a thermometer and also a small tube open to the air, both dipping below the surface of ether contained in the silver thimble. Air is aspirated through the ether, and thus its temperature, and that of the silver thimble, are lowered by evaporation, the formation of dew upon the outside being watched by means of a telescope at a distance An exactly similar empty tube, carrying a thermometer giving the temperature of the air at the time of the experiment, is mounted upon the same stand, a comparison of the two silver thimbles facilitating the exact determination of the instant at which the deposition of moisture occurs.

——, **Wet and Dry Bulb.** Consists of two thermometers mounted side by side, the bulb of one being kept moist by means of a loose cotton wick tied round it, the lower end of which dips into a vessel of water. On account of evaporation from the bulb this instrument is cooled, and indicates a lower temperature than the other, the difference depending upon the rate of evaporation and hence upon the amount of aqueous vapour present in the air. There is no simple relation between the readings and the hygrometric state; the latter is deduced therefore by reference to tables, although various empirical formulæ have been proposed. On account of its simplicity and convenience this form of hygrometer is largely used.

Hygrometric State *or* **Relative Humidity** (*Phys.*) The ratio of the amount of aqueous vapour actually present in air to the amount required for saturation at the existing temperature. This is practically the same as the ratio of the pressure of the aqueous vapour actually present to the pressure corresponding to saturation. It is generally determined by finding the "dewpoint," then hygrometric state =

$$\frac{\text{pressure of saturated vapour at dewpoint}}{\text{pressure of saturated vapour at temperature of air.}}$$

Hygrometry (*Meteorol.*) The determination of the amount of moisture that exists in the atmosphere as invisible vapour and as cloud.

Hygroscope (*Phys.*) An instrument which indicates a change in the amount of moisture present in the air. It usually depends for its action upon the property of absorbing aqueous vapour (with a consequent change of volume), possessed by many organic substances, such as hair, catgut, etc. Such instruments are generally incapable of giving exact measurements.

Hymenæa (*Botany*). A leguminous genus in the West Indies yielding timber and copal resin.

Hyoscine, Scopolamine (*Chem.*), $C_{17}H_{21}NO_4$. An alkaloid. Crystallises in white prisms, which melt at 59°. Soluble in water, alcohol, and ether. Lævorotatory. It occurs along with hyoscyamine in henbane leaves, and is prepared from these. On treatment with baryta water it yields tropic acid and a base of unknown constitution. Its hydrobromide is used in medicine. It dilates the pupil of the eye.

Hyoscyamine (*Chem.*), $C_{17}H_{23}NO_3$. An alkaloid isomeric with atropine (*q.v.*) Forms delicate white needles; somewhat soluble in water; it is lævorotatory. Baryta water resolves it into tropic acid and tropine, exactly the same as atropine is resolved into the same two substances; in fact, hyoscyamine is in all probability a compound of the lævorotatory modifications of tropine and tropic acid. It readily undergoes intramolecular rearrangement into atropine—for example, on simple melting. Like atropine, its solution dilates the pupil of the eye. Its sulphate is used in medicine.

Hypæthral (*Architect.*) A term applied to a temple when its cell or part of its cell is not roofed in. *See* CELL.

Hyperbola. The plane curve produced when a cone is cut by a plane which makes an angle with the base greater than that made by the slant side of the cone; also defined as the plane curve traced out by a point which moves so that its distance from a fixed point is always greater in a fixed ratio than its distance from a given fixed straight line.

Hyperbolic *or* **Natural Logarithm.** Logarithms calculated with the number 2·71828 . . . as a base. *See* LOGARITHMS. The hyperbolic logarithm enters into the calculation of the area of a hyperbola and many other mathematical computations. It

can be obtained by multiplying the common logarithm of the same number (given in tables of logarithms) by 2·3026.

Hypersthene (*Geol.*) One of the species of Pyroxene (allied to Augite) which crystallises in the orthorhombic system instead of the (normal) monosymmetric. It forms one of the constituents of the variety of Gabbro which is sometimes distinguished as Norite. It is a magnesium iron metasilicate (Mg . Fe)O . Si_2O. Silica = 54·2, magnesia = 24·1, ferrous oxide = 21·7 per cent. In colour it varies from green through black to brown. From Skye, Sweden, Saxony, etc.

Hypnone (*Chem.*) *See* ACETOPHENONE.

Hypo (*Photo.*) The name commonly applied in photography to SODIUM THIOSULPHATE, used for dissolving out the silver salts in fixing an image. *See under* THIOSULPHATES.

Hypobromites (*Chem.*) Salts of hypobromous acid. The hypobromites resemble in every way the hypochlorites (*q.v.*)

Hypochlorites (*Chem.*) Salts of HYPOCHLOROUS ACID (*q.v.*)

Hypochlorous Acid (*Chem.*), HOCl. Only known in water solution. Strong solutions are orange coloured; dilute solutions are colourless. The acid smells like bleaching powder solution. It is a very weak acid. On heating it easily decomposes into hydrochloric and chloric acids, but dilute solutions can be distilled without decomposition. On account of the ease with which it decomposes into oxygen and hydrochloric acid, it is a powerful bleaching agent and antiseptic. The acid is prepared by passing chlorine into water containing yellow mercuric oxide in suspension, then distilling the clear liquid; or dilute nitric acid is added to a solution of bleaching powder and the liquid distilled. It is present in chlorine water. Its salts, the hypochlorites, are obtained by acting upon metallic hydroxides with chlorine. They are oxidising agents, and on heating decompose into a chloride and a chlorate, $3KOCl = 2KCl + KClO_3$. Sodium hypochlorite is made by passing chlorine into cold and somewhat dilute caustic soda, and allowing the solution to crystallise. It always contains sodium chloride. $Cl_2 + 2NaOH = NaOCl + NaCl + H_2O$. It oxidises arsenic to arsenic acid; hence its use in Marsh's Test (*q.v.*) It oxidises urea (*q.v.*) and salts of chromium to chromates, $Cr_2(SO_4)_3 + 3NaOCl + 10NaOH = 2Na_2CrO_4 + 3NaCl + 3Na_2SO_4 + 5H_2O$. Bleaching powder (*q.v.*) yields calcium hypochlorite when it is dissolved in water.

Hypocrystalline Structure (*Geol.*) Occurs in rocks which consisted essentially of undifferentiated fluid material when they began to consolidate, but in which incipient crystallisation has commenced without being carried on to completion. Many pitchstones are of this nature.

Hypocycloid. The plane curve generated by a point in a circle which rolls round inside a larger circle. This curve is used for the lower part or flanks of the teeth of wheels.

Hypogyny (*Botany*). The condition in a flower when the calyx, corolla, and stamens arise upon the thalamus beneath the carpels.

Hyponitrous Acid, HO . N : N . OH. Has not been obtained pure; a solution is obtained by acting upon its silver salt with dilute hydrochloric acid. It easily decomposes nto nitrous oxide and water. The silver salt is formed as a yellow precipitate, when solutions of sodium nitrite and hydroxylamine sulphate are rapidly heated together to 60°, and silver nitrate added. *See* HYDROXYLAMINE.

Hypophosphites (*Chem.*) *See* HYPOPHOSPHOROUS ACID.

Hypophosphorous Acid (*Chem.*), H_3PO_2. A syrupy liquid which crystallises with difficulty. It is a powerful reducing agent, *e.g.* it reduces solutions of gold, silver, and mercury salts to the metals, and forms phosphoric acid. When heated, it yields phosphoretted hydrogen and phosphoric acid:

$$2H_3PO_2 = PH_3 + H_3PO_4.$$

It is a monobasic acid; its salts are called HYPOPHOSPHITES. The acid is obtained from barium hypophosphite by addition of dilute sulphuric acid, filtering off the barium sulphate, and carefully evaporating the solution. The hypophosphites are obtained by boiling phosphorus with a solution of the corresponding hydroxide, *e.g.*

$$P_4 + 3NaOH + 3H_2O = 3NaH_2PO_2 + PH_3$$
$$2P_4 + 3Ca(OH)_2 + 6H_2O = 3Ca(H_2PO_2)_2 + 2PH_3$$

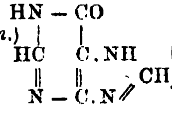
They are crystalline solids; most of them are soluble in water. They are strong reducing agents. They are used in medicine.

Hypostyle (*Architect.*) A temple in which the roof is supported by internal columns.

Hyposulphites (*Chem.*) Salts of hyposulphurous acid. Zinc hyposulphite, ZnS_2O_4, is obtained when zinc dissolves in sulphurous acid, out of contact with air. Sodium hyposulphite, $Na_2S_2O_4$, is obtained by electrolysis of sodium hydrogen sulphite; it is used to reduce indigo in dyeing. Neither of these salts has been obtained pure. Sodium thiosulphate was formerly called sodium hyposulphite, and in trade it is still known under this name.

Hyposulphurous Acid (*Chem.*), $H_2S_2O_4$. A very unstable yellow liquid, formed when a solution of oxalic acid is added to a solution of a hyposulphite.

Hypotrachelium (*Architect.*) That part of a column immediately below the capital. The term is also used to denote the grooves worked below the neck of the Greek Doric column. *See* COLUMN.

Hypoxanthine (*Chem.*)  ((Sarcine) or 6-oxy-purine)

A white crystalline solid sparingly soluble in water. It occurs along with xanthine (*q.v.*) in the animal body, *e.g.* in the spleen, thymus, etc. It is a purine derivative (*see* PURINE), and can be prepared artificially from trichlorpurine.

Hypsometer (*Phys.*) A simple arrangement for conveniently observing the temperature indicated by a thermometer immersed in the steam from water boiling under atmospheric pressure, and used instead of a barometer for determining altitudes. It practically consists of a metal vessel for boiling the water, provided with concentric vertical tubes through which the steam passes, and long enough to ensure the complete immersion of the thermometer in the steam. From the boiling point thus obtained the atmospheric pressure may be found by reference to tables, and, given the atmospheric pressure, the height above sea level may be calculated. The alteration in boiling point is *roughly* 1° C. for every 300 yards of vertical height.

Hyssop (*Botany*). An aromatic shrubby plant, *Hyssopus officinalis* (order, *Labiatæ*), bearing blue flowers. The leaves and young plants are sometimes used in cookery and also in medicine.

Hysteresis (*Elect.*) The intensity of magnetisation produced in iron by a given magnetising force depends not only upon its state at the time, but on its previous magnetic treatment, for if iron be magnetised up to any point, and the magnetising force then removed, it still retains a certain amount of "residual magnetism," and it will require a certain reverse magnetising force to bring this to zero before it begins to become magnetised in the opposite direction. Professor Ewing has applied the term hysteresis to denote the general phenomena which arise from this tendency of iron to persist in its magnetic state. The practical result is that iron cannot be carried through "cycles" of magnetisation—as, for instance, by an alternating magnetic force—without loss of energy, which appears as heat in the iron. This loss is proportional to the frequency, but increases faster than the magnetic induction "B," being, according to Steinmetz, proportional to its 1·6th power. *See also* IRON LOSSES. To give some idea of its magnitude it may be stated that in good modern charcoal iron used for armature stampings, etc., it is roughly about 4,000 ergs per cubic centimetre per cycle, when maximum induction is $B = 10,000$. Another useful way of expressing the same loss is to say that it is from 2 to 3 watts per lb. at 100 cycles per second at the above induction. Although in many ways hysteresis suggests the idea of molecular friction, Professor Ewing has shown that such an assumption is unnecessary, and he considers the loss to be due to the oscillations of the iron particles as they settle down into new positions of equilibrium under the influence of the magnetising force.

I (*Chem.*) The symbol for IODINE (*q.v.*)

—— (*Elect.*) Used to denote the INTENSITY OF MAGNETISATION (*q.v.*)

—— (*Phys., Eng., etc.*) Used to denote the MOMENT OF INERTIA (*q.v.*); the letter K is also used for the same quantity.

Ice, Action of (*Geol.*) Considerable quantities of stony debris find their way on to the surface of a glacier, as well as into its lower parts. These are transported seaward from the mountain centres, and are left at the parts where the rate of onward flow of the ice is balanced by that of melting. Some erosion of the surface in contact with the moving ice is effected where suitable conditions obtain. Icebergs and floating ice in general also act as vehicles of transport for rocky debris.

Iceberg. A large mass of ice which has been broken from the end of a glacier where this has flowed out to the deeper part of the sea. Ice fractures readily when subjected to strain, and thus tidal movements suffice to break off bergs, which may float to great distances before being completely melted. It is generally considered that the mass of the submerged portion of a berg is about nine times that of the part above water.

Ice Calorimeter (*Phys.*) An arrangement in which the heat given out by a substance in cooling from some known temperature to 0° C. is measured in terms of the mass of ice melted by it. The original form was devised by Laplace and Lavoisier, although Black had previously employed the principle. Bunsen introduced a method of determining the amount of ice melted by means of its change of volume, and his instrument is especially useful when only small quantities of a substance are available.

Iceland Moss (*Botany*). *Cetraria islandica* (class, *Lichenes*). This lichen, a native of North Europe, is used for its nutritive and medicinal properties.

Iceland Spar (*Min.*) A transparent variety of Calcite, easily cleavable; it is the variety used in the making of polariscopes (*q.v.*), and is in great demand. There were at one time large deposits of it in Iceland. *See also* CALCITE.

Ichnography. (1) A ground plan, *e.g.* the ground plan or horizontal section of a building or part of a building. (2) A plan or map.

Iconography. The science or art that treats of ancient paintings, sculptures, mosaic work, engravings on gems or metals, and especially statues and busts. The *iconography* of an individual is a description of all known portraits of such individual.

Icosahedron. A solid having twenty equal plane faces; a regular icosahedron is contained by twenty equal equilateral triangles.

Ideal Gas (*Phys.*) A gas for which the law

$$\frac{\text{Pressure} \times \text{Volume}}{\text{Absolute Temperature}} = \text{Constant}$$

is exactly true.

Ideograph, Ideogram. A symbol or figure employed in some systems of writing to suggest or express an object: a hieroglyphic.

Idiograph. A private mark or signature: a trademark.

Idiomorphic Crystals (*Geol.*) It is necessary in many cases to mark the distinction between crystals which, on the one hand, have grown up and consolidated from a fluid magma in such a manner as to press upon the growing crystals next them and thus mutually prevent each other from assuming the bounding surface proper to each of them; and, on the other hand, those which have grown and consolidated in such a manner that they have been free to take their own proper shape. For the former case the term ALLOTRIOMORPHIC is used, while for the latter, in which the crystals have assumed their own normal shape, the term used is IDIOMORPHIC. The difference of comportment is connected with the conditions of pressure under which consolidation took place.

Idle *or* **Wattless Current** (*Elect. Eng.*) When the current and the electromotive force in a circuit differ in phase (*q.v.*), the product of the two is not equal to the power. *See* ELECTRICAL POWER. If the angle of lag be Cos ϕ, then the power in watts is EC Cos ϕ. The product C Cos ϕ may be regarded as the resolved part of the current, which is in the same phase as the electromotive force E, while the remaining component of the current C Sin ϕ, differs in phase from the E.M.F. by 90°. The product EC Sin $\phi = 0$, and C Sin ϕ may be called the IDLE CURRENT.

Idle Coil (*Elect. Eng.*) In certain forms of armature a coil may at a given instant have no induced electromotive force acting in it; it is then termed an IDLE COIL.

Idle Wheel *or* **Idler** (*Eng.*) A wheel in a train of gearing which rides loose on its shaft and does not affect the ratio of the velocities of the other wheels in the train.

Idocrase (*Min.*) A basic calcium aluminium silicate formula, possibly $H(OH)_2Ca_{12}.(Al,Fe)_6(SiO_4)_{10}$. Usually, if not always, it occurs as a mineral product arising from the thermo-metamorphism of calcareous rocks. Tetragonal, occurring in prisms, yellow to brown or black. Also called Vesuvianite. From Vesuvius, Norway, Siberia, the United States, etc.

Igniter. (1) A fuse or other appliance for firing a charge in blasting. (2) The ignition device in gas engines. *See* IGNITION.

Ignition (*Eng.*) In gas, petrol, and oil engines the charge is ignited or fired in various ways. (1) FLAME IGNITION is the oldest method. A small flame was allowed to come into contact with the compressed gases through a port; the chamber containing the flame was cut off from connection with the open air at the instant before the port leading into the cylinder was opened, thus preventing the charge from exploding directly into the atmosphere. Flame ignition is now obsolete. (2) In TUBE IGNITION the charge is put into direct communication with the inside of a short ignition tube of metal or porcelain; the tube is kept at a high temperature by a burner outside. After the explosion of the charge, communication between the cylinder and the ignition tube is cut off until ignition is again required. Tube ignition is now used in the majority of stationary gas and oil engines. (3) ELECTRIC IGNITION consists in the production of an electric spark inside the cylinder at the proper instant. The current is led in by a wire passing through an insulated porcelain plug, the SPARKING PLUG; the end of this wire terminates in a platinum point, which is placed very close to another similar point which is in electrical communication with the metal work of the engine, and therefore is electrically "connected to earth." The spark thus occurs between the end of the conducting wire, which is charged up to a high potential, and a point which is at zero potential. In order to provide the current, the wire is either connected to one terminal of a small INDUCTION COIL (*q.v.*) or else to a small magneto machine (*i.e.* a dynamo with permanent field magnets). If a coil is used, it is driven by a storage battery, usually of two cells, giving an E.M.F. of about four volts. The contact breaker of the coil is worked by the HALF SPEED SHAFT. *See* PETROL ENGINE. Electric ignition is universally used on motor cars, cycles, launches, etc., driven by petrol engines, and its use is becoming increasingly common in large gas engines, especially on the Continent. (4) In a few cases AUTOMATIC IGNITION is employed; the gas becomes sufficiently hot at the instant of greatest compression to ignite spontaneously.

Ignition Plug (*Motor Cars, etc.*) *See* SPARKING PLUG.

Ignition Valve (*Eng., etc.*) A small valve which is opened just before the explosion of the charge in a gas engine, in order to effect communication between the charge in cylinder and the heated ignition chamber.

I.H.P. (*Eng.*) *See* INDICATED HORSE POWER.

Ileum (*Zoology*). The portion of the small intestine following the duodenum. It is the seat of absorption of the chyme by the agency of the VILLI (*q.v.*)

Ilex (*Botany*). A genus of the order *Aquifoliaceæ*, occurring in many parts of the world. The holly is a well known plant of the genus, and *Ilex paraguensis* is the MATÉ or PARAGUAY TEA.

Ilium (*Zoology*). The bone of the hip girdle which articulates with the sacral vertebræ of the backbone. It forms the outer portion of the pelvis, on either side.

Illuminated Manuscripts. The art of illuminating manuscripts originated in the third century, and continued until the seventeenth, the monks being the most skilful exponents. The embellishments generally took the form of drawings, more particularly ornate initial letters, executed in body colours and gold. The earliest illuminations were done with red lead, later with cinnabar. Specimens of fourth and eighth century work are to be seen at the Vatican and the Louvre. Some of the finest examples were executed between the fifteenth and seventeenth centuries.

Illuminating Power (*Light*). The illuminating power or INTENSITY of a source of light is the ratio of the illumination thrown (normally) by it on any surface to the illumination thrown (normally) by a standard source, *e.g.* a STANDARD CANDLE (*q.v.*), on the same screen, both sources being equidistant from the screen. More briefly it is the ratio of the light emitted by the given source to the light emitted by a standard source.

Illumination, Artificial. *See* ARTIFICIAL ILLUMINATION.

Ilmenite (*Min.*) An iron and titanium oxide, $FeTiO_3$; the proportions of titanium and iron vary greatly, the one replacing the other. It is one of the ores of iron, and is a common original constituent of the basic eruptive rocks, in which it is one of the first minerals to consolidate. In composition it may be regarded as a ferrous titanate; but it has a wide range in composition, and it passes in one direction into Magnetite and in another into Hæmatite. It usually occurs in the form of thin crystalline plates in which the forms proper to the mineral are but rarely developed. It belongs to the Rhombohedral System of crystallisation. A second mode of occurrence is in connection with Quartz in the crystalline schists; while yet another is that sometimes known as ISERINE, which is slightly magnetic, and is the chief constituent of MAGNETIC SAND.

Image (*Phys.*) If light diverging from a point A is made by any means to converge to a second point B, then B is termed a REAL IMAGE of A; if the light diverging from A be caused to appear to diverge from another point C, then C is termed a VIRTUAL IMAGE of A. A real image may be received on a screen; a virtual image cannot.

Imbricated (*Architect.*) Formed with one part lapping over another, so as to resemble a tiled roof.

Imide (*Chem.*) A compound containing the group $>NH$, attached to an acid residue. Examples are Succinimide, Phthalimide (*q.v.*)

$$\begin{array}{l} CH_2COOH \\ | \\ CH_2COOH \end{array} \qquad \begin{array}{l} CH_2CO \\ | \\ CH_2CO \end{array}\!\!\!> NH$$

Succinic Acid. Succinimide.

$$C_6H_4 \begin{array}{l} <COOH \\ <COOH \end{array} \qquad C_6H_4 <\begin{array}{l} CO \\ CO \end{array}> NH$$

Phthalic Acid. Phthalimide.

Imitation (*Music*). The repetition of a musical figure by another part of the harmony either at the same or at a different pitch.

Imitation-Ivory. *See* CELLULOID *and* VEGETABLE IVORY.

Imitation Parchment. Ordinary paper passed through a bath of sulphuric acid, which has the peculiar effect of "toughening" the fibres. The acid is immediately washed out and the paper dried.

Immersion (*Astron.*) The disappearance of one heavenly body behind another or in the shadow of another.

Impact. A sudden blow: a collision between two bodies: the force or forces exerted by one body on another as the result of a collision.

Impale (*Her.*) Two coats of arms may be placed upon one shield side by side, separated palewise. A husband and wife may thus blazon their escutcheon, the arms of the husband always occupying the dexter half, those of the wife the sinister half of the shield. A bishop also impales the arms of his official see with his own arms.

Impaste, Impasto (*Paint., etc.*) To lay on colours thickly in order to create a bold effect. To mix lines and points on a plate in engraving in order to represent depth of colouring.

Impedance (*Elect.*) The apparent resistance of a circuit or part of circuit when traversed by an alternating or variable current; that is, the ratio of the impressed E.M.F. to current. For steady currents this ratio is merely the ohmic resistance, but for variable currents it depends also upon the rate of variation, the self induction, and the capacity of the circuit. In dealing with alternate currents it is often necessary to consider the impedance, which may differ considerably from the resistance. Let n be the frequency of the current, L the self induction (*q.v.*) of the circuit, and R its resistance. Then, if the capacity of the circuit be neligible, the impedance is equal to

$$\sqrt{R^2 + 4\pi^2 n^2 L^2} = \sqrt{R^2 + p^2 L^2}$$

where $p = 2\pi n$. If nL be large compared with R, the impedance reduces to pL; while if R be large compared with nL the impedance is practically equal to the resistance R.

Impedance Coil (*Elect. Eng.*) A CHOKING COIL (*q.v.*)

Imperfect (*Music*). Used in connection with (1) Cadence, (2) Interval, both of which see.

Imperfect Cadence (*Music*). *See* CADENCE.

Imperial (*Paper Manufac.*) (1) Writing paper of a size 34 by 22 in. (2) Printing paper, size 30 by 22 in.

Imperial Red (*Dec.*) A bright red similar in composition to Royal Red (*q.v.*)

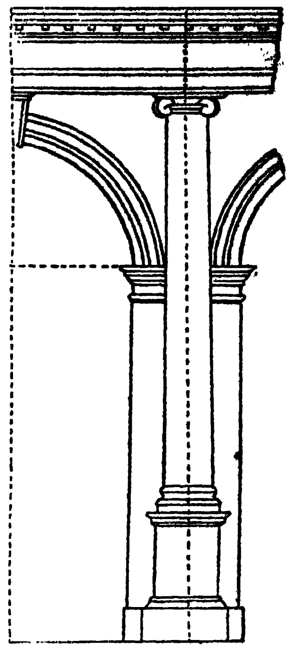
Imperials (*Build.*) Slates measuring 30 by 24 in.

Impetuoso (*Music*). Impetuously.

Imposing Stone (*Typog.*) A smooth stone or metal surface on which pages or columns of type are imposed or made into formes, and on which formes are laid for correction.

Imposition (*Typog.*) The arrangement of pages for printing, so that when the sheet is folded they may fall into proper numerical order.

Impost (*Architect.*) The horizontal mouldings crowning a pier, pilaster, or corbel, and from which an arch springs. Each order has its distinctive impost; occasionally the impost is formed of the entablature of the order.



IMPOST.

Impregnation (*Timber*). Soaking timber with a fluid in order to prevent rot; Burnett's fluid, creosote, etc., are employed.

Impression. (1) The act of impressing. (2) A copy taken by pressure from an engraved plate, type, etc. (3) The total number of copies printed at one time: an edition.

Impressionism (*Paint.*) A method of painting which aims at giving the general tone and salient features of a subject, *e.g.* the broad impression produced by some aspect of nature at first sight, excluding minute details and elaborate finish.

Imprint (*Print.*) The name of the printer or publisher (with date and place of publication) affixed to a book, magazine, newspaper, etc.

Impromptu (*Music*). A composition of an *extempore* character.

Impulse. A suddenly applied force; in engineering the term is applied especially to the force of the explosion in a gas or oil engine.

Impurities of Air. *See* ATMOSPHERE.

In (*Chem.*) The symbol for INDIUM (*q.v.*)

In Antis (*Architect.*) *See* ANTIS.

Incandescence. Glowing; self-luminous (emitting light), owing to high temperature.

Incandescent Electric Lamp. Consists essentially of a carbon filament of high resistance enclosed in a vacuum, and heated to whiteness by an electric current. *See also* ELECTRIC LIGHTING.

Incandescent Gaslight. The production of light by means of a hot, non-luminous gas flame, which impinges on a MANTLE (*q.v.*) and raises it to a high temperature, so that it becomes incandescent.

Incandescent Mantle. *See* MANTLE, INCANDESCENT.

Incandescent Tube Ignition (*Eng., etc.*) The ignition of the charge in the cylinder of a gas or petrol engine by means of a hot tube. *See* IGNITION.

Inch. *See* WEIGHTS AND MEASURES.

Inches of Rain (*Meteorol.*) *See* RAINFALL.

Inch Pound, Inch Ton (*Eng., etc.*) Units of work occasionally used; the work done when 1 lb. and 1 ton respectively are raised 1 in.

Incident Ray (*Light*). A ray which falls on the surface of a reflecting or refracting medium, but is itself wholly outside that medium.

Incisors (*Zoology*). The sharp cutting teeth in the front of the upper and lower jaws.

Inclination, Angle of (*Elect.*) The angle between the actual direction of the Earth's magnetic field at a given place and its projection on a horizontal plane. In London its value is at present about 67°.

Incline (*Mining*). A sloping shaft.

Inclined Plane. In mechanics one of the elementary types of machine, often called the mechanical powers. A gradient (*q.v.*) on a railway, or a wedge may be taken as an example.

Inclines on Railways. *See* GRADIENTS.

Incrustation (*Eng.*) The solid coating of salts from hard water, which forms on the inside of the plates of a boiler.

Incubation (*Hygiene*). The incubation period or time of development of a disease is that which elapses between actual infection and the appearance of the first signs or symptoms. Little is known of the changes which take place during this period, beyond the fact that the poison is multiplying in some part of the system.

Incunabulum, *pl.* **Incunabula** (*Print.*) A term applied to a book or books produced during the earliest period of the art of printing, more especially those printed before the beginning of the sixteenth century (1500).

Incuse (*Coins*) An impression hammered or impressed *in intaglio* on a coin.

Indamines (*Chem.*) Derivatives of Quinone di-imide. They are weak bases which form green or blue salts with acids. They are unstable; an excess of acid decomposes them into quinone and the base from which they were formed. They are important as being intermediate products in the formation of some important classes of dyes. *Cf.* METHYLENE BLUE *and* SAFFRANINE. INDAMINE or PHENYLENE BLUE, $HN:C_6H_4:NC_6H_4NH_2$, is formed by oxidation of a mixture of paraphenylene diamine and aniline. On reduction it yields paradiamide odiphenylamine, which is therefore the leuco-compound. *See* LEUCO-COMPOUNDS.

$$\left.\begin{array}{r} HN:C_6H_4 \\ H_2N.C_6H_4 \end{array}\right\rangle N + 2H = \left.\begin{array}{r} H_2N.C_6H_4 \\ H_2N.C_6H_4 \end{array}\right\rangle NH$$

Bindschedler's green and toluylene blue indamines of the formulæ

$$\left.\begin{array}{r} (CH_3)_2N\text{——}C_6H_4 \\ (CH_3)_2NCl = C_6H_4 \end{array}\right\rangle N \text{ and } \left.\begin{array}{r} (H_2N)_2.C_7H_5 \\ (CH_3)_2NCl = C_6H_4 \end{array}\right\rangle N$$

respectively.

Indanthrene. *See* DYES AND DYEING.

Indehiscent (*Botany*). A term applied to a fruit which does not open to set free the seeds (*e.g.* hazel nut, plum, etc.)

Indent (*Typog.*) A line commenced a little farther in from the margin, *e.g.* the commencement of a paragraph.

Indented (*Her.*) One of the forms given to partition lines. *See under* HERALDRY.

Indestructibility of Matter (*Chem.*) Matter can neither be created nor destroyed. Whatever changes it may undergo, whether physical or chemical, its actual mass remains unaltered, and can in general be measured by suitable experiments, and shown (within the necessary limits of experimental error) to be equal to its original mass.

Index. That which points out something. In mathematics the quantity denoting the power to which another quantity is to be raised.

—— (*Eng.*) A pointer or indicator on a gauge of any kind.

—— (*Min.*) The index of a crystal face is the reciprocal of the INTERCEPTS (*q.v.*) of that face. The index is always expressed as a whole number. Hence if the intercepts are 2 : 4 : 1, the index is written 214, instead of $\frac{2}{4}\,\frac{1}{4}\,\frac{4}{4}$ or $\frac{1}{2}\,\frac{1}{4}\,\frac{1}{1}$. When the different faces of one form are to be designated, trigonometrical sign is taken into account.

—— (*Typog.*) (1) The sign of a hand with the forefinger pointing. (2) The references, or alphabetical table of contents, generally placed at the end of a book.

—— (*Watches*). The regulator of a watch. It has two pins embracing the outer coil of the balance spring, enabling the wearer to alter the acting length of the spring. *See* BALANCE SPRING, FREE SPRING.

Index of Refraction (*Phys.*) When light passes from one transparent body to another, the ratio of the sines of the angles of incidence and refraction is a constant for the two given substances for the same wave length, and is known as the RELATIVE INDEX OF REFRACTION between the two substances, the ABSOLUTE INDEX for either of them being the value of the same ratio when light passes from a vacuum into the substance. According to the wave theory, the relative index is really the ratio of the light velocities in the two substances, and consequently it has a different value for each wave length.

Indian Hemp. *Cannabis sativa* (order, *Moraceæ*). The "Cannabis Indica" of commerce consists of the dried tops of the hemp plant, including flowers, fruit, and the exuded resin. A mixture of leaves and fruit is known as Bhang or Hashish. The resin is valued for its narcotic property.

Indian Ink. A black ink sold in sticks, and made from fine lampblack mixed with a binding material, such as parchment size or fish glue, and a little musk, camphor, and other perfume. The lampblack is exceedingly fine, and is derived from the burning of certain oils, camphor, and camphor wood. The ink is carefully dried and made into sticks, which are polished and gilded partially or wholly. Genuine Indian ink comes from China. Various attempts have been made to manufacture it in France and elsewhere, but without much success. The best varieties, when broken, show a bright jet black fracture, not unlike the fracture of genuine liquorice The perfume is to some extent an indication of the quality.

Indian Lake (*Dec.*) A lake obtained from the secretions of *Coccus Lacca*. It is now used to only a small extent, being superseded by madder. It is somewhat fugitive, but not to the extent of crimson and other lakes made from cochineal.

Indian Red (*Dec.*) A useful pigment of a dark red colour, having a slightly purplish hue, and used by the painter principally for staining or colouring. Genuine Indian red is a natural product found in India, but most of the pigment sold is artificially

prepared by the calcination of ochre and ferrous sulphate. It has no definite chemical composition. Genuine India red contains about 75 per cent. of ferric oxide. The pigment is one of the most permanent known, and it may be mixed with any other pigments without risk of producing a chemical change in them.

Indian Yellow (*Dec.*) A pigment obtained from the urine of Indian cows which have been fed on mango leaves. It is fairly permanent as a water colour, and may be used ground in oil, poppy oil being best for the purpose. It is gradually going out of use.

Indiarubber. *See* RUBBER.

Indican (*Chem.*) *See* INDIGO. This name is also applied by physiologists to potassium indoxyl sulphate. *See* INDOXYL.

Indicated Horse Power *or* **I.H.P.** (*Eng.*) Indicated horse power, *i.e.* the actual work performed by the steam (or gas) in the cylinder, as calculated from the INDICATOR DIAGRAM (*q.v.*)

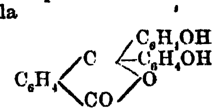
Indicating (*Eng.*) Taking an INDICATOR DIAGRAM of an engine. *See* INDICATORS *and* INDICATOR DIAGRAMS.

Indicator (*Cotton Spinning*). An instrument fixed on spinning machinery for registering the quantity of work produced.

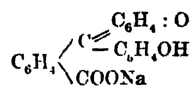
Indicator Card (*Eng.*) The card on which an INDICATOR DIAGRAM is drawn, or the diagram itself. *See* INDICATORS (*Eng.*)

Indicator Dial (*Clocks*). The "journeyman" clock, consisting only of a dial and handwork, with electrical fittings. It is under the control of, and actuated by, the "master" clock of an electric time circuit. *See* MASTER CLOCK.

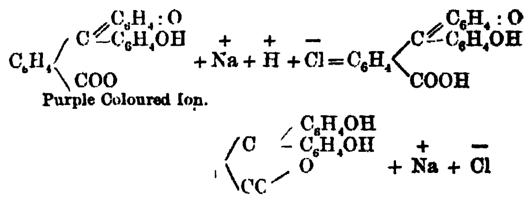
Indicators (*Chem.*) Substances used in volumetric analysis to indicate the completion of a reaction. Suppose hydrochloric acid of known strength is being added from a burette to a solution of caustic soda in order to exactly neutralise the latter and then to calculate its strength, it cannot be told by inspection when the change is completed. To enable one to judge when the reaction is completed, a substance is added which gives one colour with an alkali and another colour with an acid; the substance added is called an indicator. A good indicator must give a distinct colour change, and it must be sensitive; that is, a minute quantity of it must be sufficient for the purpose, for the change in the indicator is brought about by a reaction between it and one or other of the solutions under examination, so that the amount of the latter required to produce the change in the indicator must be negligible. In volumetric analysis indicators are used in the form of solutions of such strength that only a few drops of the indicator solution are required. INDICATORS USED FOR ACIDS AND ALKALIS:—(1) *Iodeosin* (*Erythrosin*): With acids orange, with alkalis cherry red; used in presence of ether in titrating dilute solution of acids and alkalis; can be used for $\frac{1}{10}$ or even $\frac{1}{100}$ normal solutions. (2) *Methyl Orange*: With acids pink, with alkalis yellow; unaffected by carbon dioxide. (3) *Congo Red*: With acids blue, with alkalis red. (4) *Lacmoid*: Red with acids, blue with alkalis. (5) *Litmus*: Red with acids, blue with alkalis, violet when neutral; it is affected by carbon dioxide, so that when used in titrating a carbonate the liquid must be boiled to expel carbon dioxide. (6) *Turmeric*: Yellow with acids, brown with alkalis. Its behaviour with boric acid is characteristic; when turmeric paper is dipped in boric acid solution and then dried, it is coloured reddish brown, and this colour is not changed to yellow again by hydrochloric acid. (7) *Phenolphthalein*: Colourless with acids, purple with alkalis; cannot be used for ammonia. The first four are more sensitive towards alkalis than towards acids; the others are more sensitive towards acids than towards alkalis. We will illustrate the theory of the action of indicators by an example from each class. Methyl orange has the formula $(CH_3)_2\overset{*}{N} . C_6H_4 . N : N . C_6H_4SO_2ONa$. Its action as an indicator depends on the basic properties of the nitrogen atom marked with an asterisk; for shortness we will write the formula BN. With an acid (say HCl) a salt, BN . HCl, is formed, and this in an aqueous solution is ionised thus, $BNHCl = \overset{+}{BNH} + \overset{-}{Cl}$. The positive ion $\overset{+}{BNH}$ is pink in dilute solution. On addition of an alkali (say NaOH) we have the reaction $\overset{+}{BNH} + \overset{-}{Cl} + \overset{+}{Na} + \overset{-}{OH} = BN + H_2O + \overset{+}{Na} + \overset{-}{Cl}$; that is, the methyl orange is reproduced and the pink colour changes to yellow, the colour of methyl orange in dilute aqueous solution. Phenolphthalein has the formula



Its action as an indicator depends on the fact that the substance itself is colourless in aqueous or acid solutions, while its salts have the quinoxoid structure



and are strongly coloured. The change from purple to colourless may be expressed by an equation thus:



Purple Coloured Ion.

INDICATORS USED IN OTHER VOLUMETRIC PROCESSES: Weak starch paste is used to indicate the presence of iodine, with which it forms a deep blue colour. Potassium chromate is used in the titration of neutral solutions of chlorides, bromides, and iodides by silver nitrate solution. To the chloride solution a little of the chromate is added, then the silver nitrate is run in. So long as a trace of chloride, etc., remains in solution no silver chromate can be formed and remain in the liquid. As soon as the chloride, etc., is all decomposed, silver chromate is formed and easily recognised by its dark red brown colour. Potassium ferricyanide is used in titrating a ferrous salt by potassium dichromate; this is an example of an *external* indicator. In this case the indicator is placed in drops on a white tile, and a

drop of the liquid being titrated is added to the indicator. So long as ferrous salt remains, a deep blue colour is produced. Many other indicators are used, but less commonly than the above. Many of the above indicators are used in special cases in the form of papers; unsized paper is dipped in a solution of the indicator and then dried. The ordinary litmus and turmeric papers are familiar instances. Some of these papers are wonderfully delicate tests for acid or alkaline reaction; *e.g.* azolithmin paper (*see* LITMUS) will show an alkaline reaction with solutions of caustic soda or ammonia of strengths little over $\frac{1}{5000}$ normal and $\frac{1}{1000}$ normal respectively.—W. H. H.

Indicators *and* **Indicator Diagrams** (*Eng.*) An INDICATOR DIAGRAM is a figure showing the relations between the pressure and volume of the WORKING SUBSTANCE (gas or steam, etc.) in the cylinder of an engine. It may be drawn from purely theoretical assumptions, as in the case of the diagram representing CARNOT'S CYCLE (fig. 1). In this case the working substance is originally at a pressure P_1 and a volume V_1. In the first operation it is compressed adiabatically to a volume V_2, the pressure meanwhile rising to P_2. The work done *on* the substance in this operation is represented by the area of the figure $P_1P_2V_2V_1$. It is then allowed to expand isothermally to a volume V_3, the pressure falling to P_3, and the work done *by* the substance is represented by $P_2P_3V_3V_2$. In the third operation it expands adiabatically to a volume V_4 and pressure P_4, the work done *by* it being represented by the area $P_3P_4V_4V_3$. It is finally compressed to its original pressure and volume, the work done *on* the substance being given by the area $P_4P_1V_1V_4$. The net work done by the substance during these four operations is given by the difference of the areas $P_2P_3P_4V_4V_2$ and $P_4P_1P_2V_2V_4$; that is, the area of the curved part of the figure, $P_1P_2P_3P_4$. This cycle of operations is purely theoretical, and has never been realised in practice. A theoretical representation of the changes in pressure of the steam in the cylinder of a steam engine may be arrived at as follows: Let A (fig. 2) be a cylinder with a piston B, and two pipes or ports C and D, each fitted with a tap or valve which can be opened or closed as required, C being the INLET or STEAM PORT, by which steam can be admitted, and D the OUTLET or EXHAUST PORT, by which the steam can escape. Let B be at the beginning of its stroke, so that the volume of the space between the piston and the end of the cylinder is very small, and let the pressure of any steam or other gases in the space be P_0. If at this instant D be open to the air, then P_0 will equal the pressure of the atmosphere. Close D and open C. The pressure inside will instantly rise to that of the steam; let this be P_1, represented by the point P_1 on the diagram. The piston will now begin to move, and if steam continue to enter the cylinder the pressure will remain at P_1. When the piston has advanced to E, let C be closed and the supply of steam be consequently cut off. The piston will still continue to move, being driven by the pressure of steam behind it; but this will no longer be P_1, but will gradually fall as its volume increases, in a manner indicated by the line P_1P_2 on the diagram, which is approximately a hyperbola. When the piston reaches F, let D be again opened; the pressure will drop to P_0, and if the return stroke now commences, steam will escape from D at this pressure, or very nearly so. The Indicator Diagram will have the form shown by the lower part of the figure, and if we calculate the average height of this figure $P_0P_1P_1P_2P_0$, we can find the average pressure of the steam during the stroke. To find the average height, we measure the total area of the diagram either by dividing it up into strips and applying SIMPSON'S RULE (*q.v.*) or by using the PLANIMETER (*q.v.*) Suppose the area to be a square inches, then if l be the length P_0P_0 in inches and x the average height, which we wish to find, we have $xl = a$ and $x = \frac{l}{a}$. We know the original pressure of the steam, and therefore know how many pounds pressure are represented by the line P_0P_1, and by proportion we can find the average pressure represented by x. The total amount of work done on the piston during one stroke of the engine is then found as follows: Let a be the area of the piston in square inches, p the average pressure during the stroke, l the length of stroke in feet; then pal is the work (in foot pounds) done in one stroke or half a revolution. If the steam act on both sides of the piston, the work in one revolution is $2pal$, and if n be the number of revolutions per minute, the total work done on the piston per minute is $2npal$ foot pounds or $\frac{2npal}{33,000}$ horse power. This is termed the INDICATED HORSE POWER (I.H.P.) of the engine.

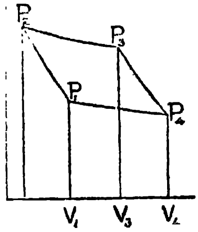


FIG. 1.

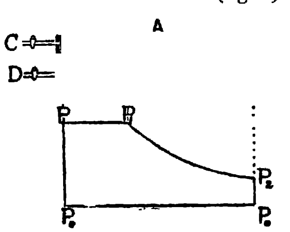


FIG. 2.

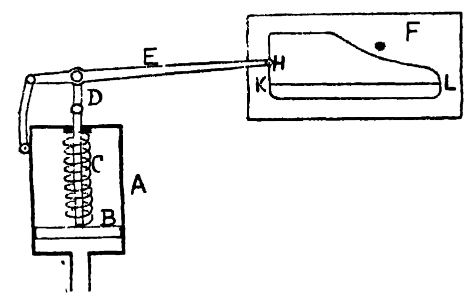


FIG. 3.

AN INDICATOR is an instrument for actually drawing the indicator diagram by the action of the steam itself. A small cylinder A (fig. 3) communicates directly with one end of the cylinder of the engine by a tube at the bottom. A piston B fits smoothly in A, and is pressed down by a spring C, whose strength is so adjusted that the piston will rise a convenient distance when the maximum steam pressure is exerted on B. The motion of B is communicated by a piston rod and link at D to a lever E, which carries a pencil at H. The pencil marks its position at each instant on a card F, which moves backward and forward at

the same rate as the piston of the engine. If F be stationary, H will describe a vertical line, the line of no volume, and the position of H shows the pressure of the steam at the instant; while if B be at rest (*i.e.* the inlet be cut off from connection with the cylinder by a tap), then if F move backward and forward, we shall obtain a horizontal line KL, the line of zero or atmospheric pressure. If both F and B move, the pencil will trace out a closed figure, which shows the relation of the pressure and volume of the steam at each instant of the stroke. This figure is the actual INDICATOR DIAGRAM for the engine; it will differ from the theoretical form shown in fig. 2, usually being more irregular in outline and having rounded corners. Thus in fig. 4 the piston of the engine begins to move before the steam in the cylinder has reached its full value, causing the corner B to be rounded off; then the steam is admitted at full pressure, giving the line BC, which is nearly horizontal; then the cut-off occurs and expansion begins. If the admission port were closed instantaneously, the corner C would be quite sharp, but in practice this is never the case. Expansion goes on during the remainder of the stroke till the exhaust port opens, and the pressure falls from D to E; the return stroke now occurs, and steam escapes from the cylinder at nearly constant pressure (shown by the line EA). If the exhaust port be closed slightly before the end of the stroke, the pressure of the remaining steam rises, through compression, producing what is termed CUSHIONING, which is shown by the rounding off of the corner A. If the cut-off occur earlier in the stroke, the diagram takes the form shown in fig. 5. If the engine be fitted with a condenser, the pressure of the steam falls to a value less than the atmospheric pressure, and the diagram extends below the ATMOSPHERIC LINE KL (fig. 3), which is drawn when the piston of the indicator remains at rest, while the card F moves in unison with the piston of the engine. A somewhat different form of indicator is used for gas engines, or in any engine where the changes of pressure are very rapid; but the essential principle is the same. The diagram for a typical gas engine using the Otto Cycle (*see* GAS ENGINES) is given here for completeness (fig. 6). The line AB is marked out while the charge is being drawn into the cylinder. The admission valve then closes, and the charge is compressed, giving the line BC (the COMPRESSION LINE). Explosion occurs and the pressure rises, giving the line CD. If combustion were complete before the piston began to move, this line would be vertical. At D the expansion of the exploded gases sets in, and the line DE (the EXPANSION LINE) shows the pressure during the forward stroke. At E the exhaust valve or port opens, and during the next return stroke the exhaust or burnt gases are expelled, the pressure again falling to the valve at A, and the cycle is complete. The area of the shaded portion is proportional to the work done in one cycle (two revolutions), and the average pressure is, as before, the average height of this portion.

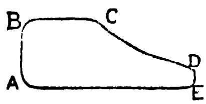


FIG. 4.

FIG.

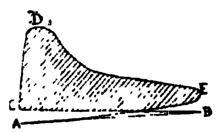


FIG.

Indifferent Equilibrium. A body is in indifferent equilibrium if on receiving a small displacement it does not experience any force tending either to increase or decrease the displacement.

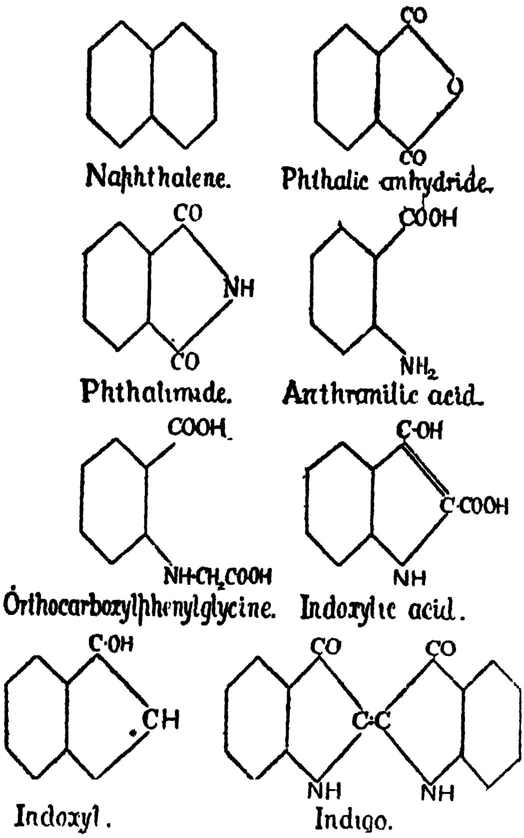
Indigo (*Chem.*) $C_6H_4 \left< {CO \atop NH} \right> C : C \left< {CO \atop NH} \right> C_6H_4$

A dark blue solid which exhibits a coppery lustre when rubbed; insoluble in water, alcohol, ether; soluble in hot aniline, in hot naphthalene, and in melted paraffin. It can be crystallised from the former. On heating, it sublimes, forming lustrous coppery prisms. Its vapour has a density corresponding to the above formula. Alkaline reducing agents dissolve indigo, forming INDIGO WHITE,

$$C_6H_4 \left< {C.OH \atop NH} \right> C - C \left< {C.OH \atop NH} \right> C_6H_4.$$

This property is used in dyeing cotton, the reducing agents employed being very various; *e.g.* lime and zinc dust, alkaline hyposulphite (*q.v.*), electrolytic reduction. Indigo white is a white crystalline solid, soluble in alcohol. When cotton is dipped in the alkaline solution and then exposed to air, the oxygen soon oxidises the indigo white to indigo again, and the blue so obtained is "fast." With sulphuric acid indigo forms, according to the strength of acid employed, mono-, di-, and trisulphonic acids. The disulphonic acid is soluble in water, and is used in wool dyeing; its sodium salt comes into trade as a paste under the name indigo carmine. On oxidation with nitric acid or chlorine water, indigo yields ISATIN (*q.v.*); on distillation with caustic potash it yields ANILINE (*q.v.*) Indigo is obtained to a very small extent from woad (*Isatis tinctoria*); to a much larger extent in India and South America from the leaves of the indigo plant (*Indigofera tinctoria*). These plants contain a glucoside indican. When the leaves of the Indian plant are soaked in water the glucoside yields a sugar and a substance INDOXYL (*q.v.*), which on oxidation yields indigo. The natural indigo is not a pure substance; it contains indigo red, indigo brown, and indigo gelatine. Pure indigo may be obtained from it by sublimation, or by crystallisation from aniline, or by conversion into indigo white and allowing the alkaline solution of the indigo white to oxidise in the air. The pure indigo is called INDIGOTIN. Large quantities of indigo are now made synthetically by the Baden Aniline & Soda Company. To give some idea of the scale on which artificial indigo is made, the export of indigo from the provinces of Calcutta and Madras fell in value by 43 per cent. between the years 1895-6 and 1899-1900; also in 1900 the above company were converting yearly 2,000,000 kilos of glacial acetic acid into monochloracetic acid in the manufacture of artificial indigo. A further impetus was given to the manufacture in 1901 by the Prussian Army order that all the blue military uniforms must be dyed by artificial indigo. The synthesis employed is Heumann's. Naphthalene, the most abundant and cheapest coal tar product, is converted into phthalic anhydride by fuming sulphuric acid and mercuric sulphate. The anhydride yields phthalimide with ammonia, and bromine and alkali convert the phthalimide to anthranilic acid. The latter with monochloracetic acid yields orthocarboxyphenyl-

glycine, which on fusion with alkali and action of air yields indoxyl and then indigo.



Many other syntheses of indigo are known. *See also* DYES AND DYEING.—W. H. H.

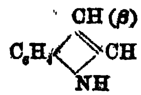
Indigo (*Dec.*) A dark blue produced from a number of different plants, including *Indigofera tinctoria* and *Indigofera anil* (order, *Leguminosæ*). It is a useful blue for the house painter, although it cannot be mixed with lead or lead chromates. Artificial indigo is now an established commercial success, and bids fair to drive the natural article from the market. For painting purposes indigo may be employed for producing effects difficult to obtain in any other way.

Indigotin (*Chem.*) *See* INDIGO.

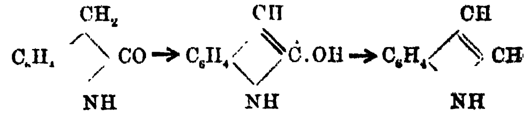
Indigo White (*Chem.*) *See* INDIGO.

Indium, In. (*Chem.*) Atomic weight, 114. A soft white metal; melts at 176°; on heating strongly it burns with a violet flame; it dissolves in dilute acids, forming indium salts; its salts when acted on in solution by zinc or cadmium deposit indium. Forms three chlorides, InCl, $InCl_2$, $InCl_3$. The first two are decomposed by water, giving the metal and $InCl_3$. The metal belongs to the same group as aluminium. It occurs to a minute amount in zinc blende, in which it was discovered by the spectroscope; its spectrum contains two bright blue lines.

Indogen (*Chem.*) *See* INDOXYL.

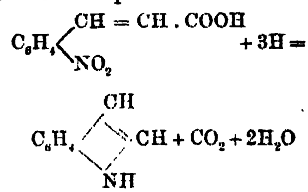
Indole (*Chem.*), 

Crystallises in shining petals; melts at 52°; peculiar and rather disagreeable smell; volatile in steam; soluble in hot water, in alcohol, ether, and benzene. It is a weak base. It is a pyrrol derivative. Indole is formed by putrefactive changes in the intestines; also when albumins are melted with caustic potash. Formed: (1) By reduction of oxindole with zinc and hydrochloric acid—

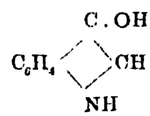


Tautomeric Forms.

(2) By reduction of orthonitrocinnamic acid with zinc dust and caustic potash—

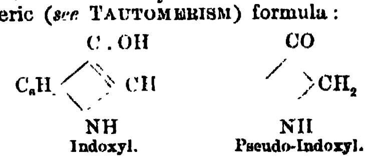


It was first obtained by reduction of indigo. On oxidation with ozone it again passes into indigo. *See also* SKATOLE.

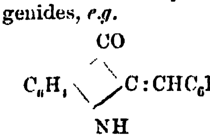
Indoxyl (*Chem.*), 

(β-oxyindole).

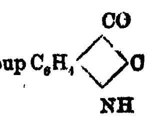
An unstable oil which dissolves in water with yellow fluorescence. In alkaline solution it is easily oxidised by air to indigo. With potassium pyrosulphate it forms potassium indoxyl sulphate, $SO_2<^{OK}_{C_8H_6NO}$, a substance which occurs in urine; it arises from indole which is formed in the intestines. Indoxyl is an intermediate product in the synthesis of indigo (*q.v.*) It is formed from indigo by melting with caustic potash out of contact with air. In some of its reactions indoxyl behaves as if it had the tautomeric (*see* TAUTOMERISM) formula:



Thus with aldehydes and ketones it yields Indogenides, *e.g.*



Benzaldehyde indogenide.

Indogen is the name given to the group 

Induced Current (*Elect.*) The current produced in a conducting circuit when the number of magnetic

lines of force passing through it is varied. *See* INDUCTION.

Induced Magnetism. The magnetism produced in a piece of iron (or steel) which was previously unmagnetised, by placing it in a magnetic field.

Inductance (*Elect. Eng.*) (1) In general terms, equivalent to INDUCTION (*q.v.*) (2) The COEFFICIENT OF SELF INDUCTION of any circuit. *See* SELF INDUCTION.

Induction Coil (*Elect.*) An apparatus for obtaining a very small current at a very high voltage from a battery current of low voltage, and hence really a transformer especially adapted to work with a continuous current from a few cells. It consists essentially of an iron core, usually of wire, wound with two independent windings, the first or PRIMARY being merely two or three layers of stout wire. This is connected to the battery through a "contact breaker," the result being to magnetise and demagnetise the core at a rate determined by the stiffness of the contact breaker spring. The lines of force thus produced cut the SECONDARY coil, wound over the primary, setting up in it an induced E.M.F. whose magnitude depends only upon the number of lines of force, the number of turns, and the rate at which the lines cut the turns, and thus may be made great enough to produce sparks of considerable length by sufficiently increasing the number of secondary turns. The greatest care is necessary in insulating the secondary from the primary, and also the various turns of the secondary from each other, and large coils usually have the secondary built up of numerous independent small coils wound in thin vertical slices separated by discs of insulating material.

Induction, Electro-Magnetic. When a conductor is moved at right angles to the lines of force in a magnetic field (*i.e.* when there is relative motion), an electromotive force is set up in it which is independent of its material, and, except indirectly, of its size and shape also; it depends only upon the number of lines of force cut and the time in which they are cut. In other words, the rate of cutting is a measure of the E.M.F. If the conductor and the field are not at right angles, only the resolved component of the motion which is at right angles to the lines of force is effective, no E.M.F. being produced by the component of the motion along the lines of force. The fact that an induced E.M.F. is independent of material is the basis of the definition of unit E.M.F., which is naturally defined as being the E.M.F. produced in a conductor cutting one line of force per second. It should be noticed that the induced current cannot be so simply stated; it may not even exist, and in any case its magnitude depends upon the resistance of the conductor and of the rest of the circuit. *See also* INDUCTION (SELF, MUTUAL, MAGNETIC, *etc.*)

——, Electrostatic. When a neutral body becomes electrified by mere proximity to a charged body without actually receiving any of its charge, it is said to be charged by induction. Another way of expressing the same fact is to say that if lines of electric force pass in or out of a conductor, they end and begin in electric charges, and hence a conductor necessarily becomes charged when placed in an electrostatic field of force.

——, Magnetic. If a piece of iron, steel, etc., previously unmagnetised, be placed in a magnetic fluid, it becomes a magnet. It is then said to be magnetised by induction. *See* MAGNETIC INDUCTION.

Induction, Mutual (*Elect.*) When a current is started or stopped, or varied in strength in one circuit, it will produce an induced E.M.F. in a neighbouring and independent circuit, because some of the lines of force produced in the first circuit cut the second.

——, Self (*Elect.*) When a current flows in a circuit, a magnetic field of greater or less strength is always produced, and this field, while appearing or disappearing, necessarily cuts the circuit itself, and in so doing sets up an induced E.M.F. With steady currents this effect only occurs at its starting or stopping, the result being that the rise of a current is opposed by the self-induced E.M.F. in the opposite direction, and its stoppage also opposed by another self-induced E.M.F. in the same direction, the effects being most conspicuous in the case of coils of wire having iron cores. The result is that an electric current behaves as if it possessed inertia, and is unable to start or stop instantaneously.

——, Self, Coefficient of (*Elect.*) This may be defined for any circuit or part of a circuit as being numerically equal to the "amount of cutting" which takes place when unit current is stopped or started in that circuit. For instance, if unit current produces l lines of force, and these lines cut n turns in appearing or disappearing, then $l \times n$ is the "amount of cutting," and is the coefficient of self induction. This is the absolute unit, the practical unit being the HENRY, which is 10^9 absolute units. It is usually denoted by the letter L.

Induction Valve, Port, etc. (*Eng.*) The valve or port by which steam (or gas) enters the cylinder of an engine: more usually termed an ADMISSION VALVE or PORT.

Inductive Capacity, Specific (*Elect.*) *See* SPECIFIC INDUCTIVE CAPACITY.

Inductor Alternator (*Elect. Eng.*) An alternating current dynamo in which the change of flux through the armature coils is produced by the motion of masses of soft iron, both field magnets and armature coils remaining at rest. *See* DYNAMO.

Indulines (*Chem.*) Dyes ranging in shade from red to dark blue. They are insoluble in water, but soluble in alcohol. They are divided into classes as follows:

Benzene induline, $HN : C_6H_3 \genfrac{<}{>}{0pt}{}{N}{N} C_6H_4.$

Isorosinduline, $HN : C_6H_3 \genfrac{<}{>}{0pt}{}{N}{\underset{C_6H_5}{N}} C_{10}H_6.$

Rosinduline, $HN : C_{10}H_5 \genfrac{<}{>}{0pt}{}{N}{\underset{C_6H_5}{N}} C_6H_4.$

Naphthinduline, $HN : C\ H \genfrac{<}{>}{0pt}{}{N}{N} C_{10}H_6.$

From these many derivatives are obtained by introducing other radicals in place of hydrogen in the HN, and benzene and naphthalene residues on the left and right of the formulæ. The preparation of the simpler indulines consists in heating together a mixture of amidoazobenzene, aniline, and aniline hydrochloride. Rosinduline is prepared by heating benzene-azo-α-naphthylamine with aniline and aniline hydrochloride.

Industrial Soaps. A term used to describe that class of soap used for special purposes, such as ox gall soap, which is useful for scouring woollen goods and cleaning carpets, soap for silk dyers, fulling soap, etc.

Inequalities, Secular (*Astron.*) Perturbations of the celestial bodies so small that they only become important in a long period of time.

Inertia. The property of matter whereby it resists the action of a force which tends to change its state of rest or of uniform motion in a straight line.

——, Moment of. A quantity which takes the place of mass in the mechanics of rotating bodies. It is obtained by multiplying the mass of each particle in the rotating body by the square of its distance from the axis of rotation, and summing the series to an infinite number of terms. It can be shown that the ordinary equations of linear motion are true for rotatory motions if moment of inertia be written in place of mass, and angular velocity in place of linear velocity; for instance, the energy of a rotating body is $\frac{1}{2} I\omega^2$, where I = moment of inertia and ω = angular velocity. The moment of inertia of a body is often written in the form $I = Mk^2$, where M is its mass and k the radius of gyration; *i.e.* that distance from the axis of rotation at which all the mass must be placed in order that its kinetic energy may be unaltered.

Inescutcheon *or* **Shield of Pretence** (*Her.*) A small shield placed on an escutcheon. The arms of Ulster are placed in this manner on the shields of baronets.

Infection. *See* CONTAGION.

Infectious Diseases (*Hygiene*). *See* DANGEROUS INFECTIOUS DISEASES.

Inferior Conjunction (*Astron.*) Two or more bodies are said to be in conjunction when they are in the same longitude or right ascension. They are in inferior conjunction when they are on the same side of the sun.

Inferior Figures *or* **Letters** (*Typog.*) Small letters or figures which range at the bottom of an ordinary letter or figure, thus: $_2$, $_3$, $_1$. The reverse of "superior."

Inferior Planets (*Astron.*) Those whose orbits lie between that of the earth and the sun, *i.e.* Mercury and Venus (*q.v.*)

Infiltration (*Geol.*) A mode of action connected with the tendency of fluids to spread to wider areas under the combined influence of surface tension and gravitation. Water containing any one of various substances in solution may thus carry them into various parts of the Earth's crust below and around their starting point, and may eventually leave these substances in new positions. Iron, silica, carbonate of lime, carbonate of magnesia, and other substances may be introduced into rocks by this means.

Inflation (*Cycles*). *See* TYRES.

Influence Machine (*Elect.*) A general name for static electrical machines which make use of the principle of induction instead of friction. *See* HOLTZ, WIMSHURST, *and* VOSS MACHINES.

Infula, *pl.* **Infulæ** (*Cost.*) The pendent lappet or lappets hanging from a bishop's mitre and falling on the shoulders. Originally the term was applied to a form of mitre itself.

Ingate (*Foundry*). The gate (*q.v.*) by which fluid metal enters a mould.

Ingenhausz's Experiment (*Heat*). An experiment to compare the conductivities of different materials in the form of rods or bars of equal section and similar state of surface. The bars are coated with wax, and one end of each kept at a fixed temperature by means of boiling water or other convenient method. When a steady state is reached, the wax is melted to different lengths along the bars, and the conductivities are proportional to the squares of the lengths of the melted wax.

Ingot (*Met.*) A mass of metal which has been poured into a mould in order to give it a shape (usually that of a short rectangular bar) convenient for handling, transit, or storage.

Ingrain (*Dec.*) A class of wallpapers now very popular, made from dyed pulp, which gives the prevailing colour to the paper in contradistinction to ordinary wallpapers which are "grounded" or covered with distemper colour. Ingrains are often used quite plain, *i.e.* without pattern, but some are printed with a pattern in very light colours. The surface of most ingrains is absorbent, almost like blotting paper, and the usual method of applying plenty of paste and allowing it to soak cannot successfully be followed with them; as little moisture as possible must be used. In all cases lining or plain paper should be hung underneath, especially if old paper is left on the wall. Even when properly hung, ingrains are very apt to fade. The dyes employed are mostly fugitive. *See* PAPERHANGING, WALLPAPERS.

Initial Condensation (*Eng.*) Condensation of steam on first entering a cylinder. The loss of energy thus caused is largely prevented by keeping the cylinder hot by means of a STEAM JACKET (*q.v.*)

Initial Pressure (*Eng.*) The pressure at which steam first enters a steam engine cylinder, or the pressure of the gas in a gas engine cylinder at the instant after the explosion has occurred.

Injection (*Eng.*) Applied generally to the forcing of a small stream of fluid into a vessel, especially to the forcing of water into a boiler by means of an injector (*q.v.*), or into the condenser of an engine.

—— (*or* **Jet**) **Condenser** (*Eng.*) *See* CONDENSER.

Injector (*Eng.*) A piece of apparatus for forcing water into a boiler. A jet of steam mingles with a portion of the supply of feed water, and by its condensation causes a partial vacuum, into which the main portion of the feed water rushes with great velocity. The kinetic energy of the moving water is sufficient to force a steady stream of feed water into the boiler.

Inker (*Print.*) One of the rollers in a printing machine which apply ink to the type.

Inks. Writing ink is a mixture of ferrous and ferric gallates, to which gum has been added. It is made from nutgalls and ferrous sulphate (copperas), the gum serving to keep the gallates in suspension. The galls are sometimes replaced to a greater or less extent by use of logwood and indigo extract. Coloured inks are now usually made from coal tar dyes, *e.g.* eosin or magenta for red ink. SYMPATHETIC INKS are of various kinds. The writing may be done with a solution of cobalt nitrate, when it will be colourless till it is warmed; the heat will turn it blue. The writing may be done with silver

nitrate, when it will turn black on exposure to sunlight. The writing may be done with a solution of copperas, and afterwards made visible by washing with an extract of gallnuts. PRINTING INK is a mixture of boiled linseed oil and lampblack. Coloured inks are prepared by using a suitable pigment in place of the lampblack (vermilion, oxide of lead, lead chromate, Prussian blue, ultramarine, etc.) MARKING INK should contain silver nitrate, Indian ink, and gum.

Inlets for Fresh Air. *See under* SANITATION.

Inlier (*Geol.*) An exposure of rock which is completely surrounded by higher or newer rocks. It is a term which is usually restricted to sedimentary rocks occurring under the conditions named, but it is also applied to similar exposures of intrusive masses. It is a correlative to OUTLIER (*q.v.*)

Inoculation (*Hygiene*). A method of communicating a disease in a mild form by directly introducing infectious matter into the system. This renders man more or less insusceptible to such disease.

Inorganic Chemistry. A term long applied to the study of all the elements and their compounds, excepting those of carbon, which were supposed to be produced by or intimately connected with organic processes, *i.e.* processes carried on in or by the agency of animals and plants. The distinction between inorganic and organic chemistry was shown to be unreal and arbitrary when the synthesis of carbon compounds from their elements became general.

Inorganic Evolution (*Astron.*) An hypothesis which has many strong facts to support it, *viz.* that all the various kinds of matter, all the various so called chemical elements, may be built up in some way of the same fundamental substance.

Inorganic Ferments (*Chem.*) *See* ENZYMES.

Inosite *or* **Hexahydrohexaoxy Benzene** (*Chem.*), $C_6H_6(OH)_6$. A crystalline solid which exists in a dextro, a lævo, and an inactive form. It occurs in muscle (it is sometimes called muscle sugar), in the liver, and is largely distributed in the vegetable kingdom.

Insect Wax (*called also* **Chinese Wax**). Is secreted by the insect *Coccus ceriferus*. It is white, odourless, tasteless, and almost as hard as Carnauba wax (*q.v.*) It is used in Japan and China for making candles, sizing paper and cotton goods, but is not exported excepting in small quantities.

Insertion Joint (*Eng.*) A joint in pipes which is made watertight by the use of a ring or washer made of indiarubber or rubber alternating with layers of canvas.

Inset (*Print.*) A sheet, or the part of a sheet, which falls inside another sheet in sequence of pagination.

Inside (*Lace Manufac.*) A term that includes all the most delicate working parts of a lace machine, the principal being the "combs" and "points."

Inside Calipers. Calipers (*q.v.*) with the points turned outward, for measuring the internal diameter of a cavity.

Inside Crank (*Eng.*) A crank formed on the shaft so as to lie between the bearings; the most usual form.

Inside Cylinders (*Eng.*) Cylinders of a locomotive which are fixed inside the frame.

Inside Gouge (*Carp., etc.*) A PARING *or* SCRIBING GOUGE (*q.v.*)

Inside Lap (*Eng.*) *See* SLIDE VALVE.

Inside Lead (*Eng.*) *See* SLIDE VALVE.

Insolation (*Phys.*) Exposure to sunlight for the purpose of producing phosphorescence.

Inspection Chamber (*Sanitation*). A chamber at the junction of drains to allow of inspection. *See* DRAINS.

Installation. Machinery, plant, apparatus, etc., which is set up in a more or less permanent manner, *e.g.* machinery comprising engines, boilers, dynamos, switch boards, cables, wires, lamps, etc., for supplying electric light.

Instantaneous Centre. If two bodies are moving in any manner in a plane, their motion at any given instant can be fully represented as a rotation about a certain point, termed the INSTANTANEOUS or VIRTUAL CENTRE. This point is the intersection of two normals (the VIRTUAL RADII) drawn to the directions of the motion of the respective bodies.

Instantaneous Value (*Elect.*) The value of a current or electromotive force at any given instant. If the current (or E.M.F.) vary harmonically, then the instantaneous value (A) at time t is given by the equation

$$A = A_0 \sin pt,$$

where A_0 is the maximum value, and p a constant depending upon the frequency.

Instantaneous Vice (*Eng., etc.*) A vice in which the grip is obtained by some form of cam or rack. This can be disengaged at will, and a large movement of the jaws rapidly effected, the loss of time being much less than when the jaws are operated by a screw, as in the ordinary vice.

Instrumentation (*Music*). The art of orchestral writing.

Insulate, Insulation (*Elect.*) The separation of conductors from other conductors by means of non-conducting materials; also frequently used for the material itself. *See* INSULATING MATERIALS.

Insulating Materials *or* **Insulators** (*Elect.*) A perfect insulator is a substance which does not conduct electricity. No really perfect insulator has been discovered yet. In practical use the substances which approach the required conditions most nearly are those with very high resistance, *e.g.* glass, porcelain, ebonite, guttapercha, rubber, various resins and waxes, certain minerals (*e.g.* mica), silk, and various oils. Gases are almost complete insulators from the ordinary point of view of the practical electrician, though a gas may convey electricity freely at low pressures. The specific resistance (*q.v.*) of some important insulating materials is as follows:

Mica	$8{\cdot}4 \times 10^7$	megohms.
Glass	9×10^7	"
Guttapercha	$4{\cdot}5 \times 10^8$	"
Shellac	9×10^9	"
Ebonite	$2{\cdot}8 \times 10^{10}$	"
Paraffin wax	$3{\cdot}4 \times 10^{10}$	"

The above resistances are all given at ordinary temperatures.

Insulating Paint. A paint made of fossil gum, a pigment, and a vehicle, usually spirit or naphtha, intended for use in connection with electrical appliances, being unaffected by the current.

Insulating Resistance (*Elect.*) *See* INSULATING MATERIALS.

Insulator (*Elect.*) A support or coating composed of some INSULATING MATERIAL (*q.v.*); applied to a conductor in order to insulate it.

Intaglio (*Architect.*) A species of sculpture in which the subject is carved into the ground so as to form a hollow. *See* CAVO RELIEVO, BASSO RELIEVO, ALTO RELIEVO, *and* MEZZO RELIEVO.

—— (*Art*). (1) A figure engraved or cut into a substance so that the design is below the surface. (2) A gem with a figure or device cut in the foregoing manner, *e.g.* a seal. An *intaglio* or incised carving is the reverse of a CAMEO (*q.v.*)

Intensification (*Photo.*) Increasing the opacity of the image to actinic rays either by depositing additional silver from a solution of its salt or by the use of a metallic salt (very frequently mercury), followed by ammonia. Intensification does not add to the detail in the picture; it merely strengthens the image already formed.

Intensifiers (*Photo.*) Solutions used for INTENSIFICATION (*q.v.*) If mercuric chloride be employed, the negative is soaked in a solution of this until bleached, and, after well washing, blackened by means of either sodium sulphite, ammonia, or by the application of a ferrous oxalate developer.

Intensity of Light. The quantity of light which falls upon a unit area of the illuminated surface. Intensity is usually measured by comparison with an arbitrary standard, such as the light from a standard candle. *See also* ILLUMINATION.

Intensity of Magnetisation. A measure of magnetic strength based upon the idea of magnetic poles and action at a distance. It is numerically equal to magnetic moment divided by volume, and hence in the ideal case of a uniform bar having free poles wholly on the end surfaces it means the number of unit poles per unit area of end surface.

Interbedding (*Geol.*) A term used as a correlative to INTRUSIVE. It is thus applied equally to rocks of volcanic origin and to normal sediments, and conveys the idea of repeated alternations of conditions favourable to the deposition of beds of rock.

Interceptor (*Sanitation*). *See* DISCONNECTING TRAPS.

Intercepts (*Min.*) The lengths of the axes cut off by the crystal face or by the extension of the plane of that face. *See* SYSTEMS, CRYSTALLOGRAPHIC. The simplest example is the regular octahedron (of the cubic system), where the intercepts are all equal. The intercepts are thus, $1:1:1$. The face of the cube is parallel to two of the axes, but cuts the other at unity, hence the intercepts are $1:\infty:\infty$. The intercepts are always expressed as whole numbers, and these numbers are usually of low value, rarely more than ten. Thus, if the amount of one axis cut off by a face was half the unit length of that axis the intercepts are written $2:4:1$ instead of $1:2:\frac{1}{2}$.

Interchangeable Parts. In many modern machines it is customary for the makers to supply spare parts, which can be substituted for damaged or worn parts, without alteration or fitting. The production of strictly interchangeable parts is only possible when they are made very accurately to gauge, and depends very largely on the use of automatic machinery in the manufacture of the articles. Cycles, motor cars, seagoing machinery, and many machines required for export are some of the best examples of mechanism whose value is much increased by the interchangeability of parts.

Intercolumniation (*Architect.*) The space between two columns measured immediately above the bases, except in the case of the Greek Doric order, in which the intercolumniation is measured at the lowest part of the columns. *See* PYCNOSTYLE, SYSTYLE, EUSTYLE, DIASTYLE, ARÆOSTYLE, MONOTRIGLYPH, DITRIGLYPH, *and* TRITRIGLYPH.

Interdentils (*Architect.*) The space between two DENTILS (*q.v.*)

Interference (*Phys.*) A term chiefly used in connection with light waves, but applicable to wave motion generally, and really meaning that when two or more waves traverse the same space the net result is the algebraic sum of the separate disturbances. Hence two waves of equal frequency and amplitude will have a resultant zero when a phase difference of half a wave length (or any multiple of half a wave length) exists between them, and will, conversely, enhance each other's effect when the phase difference is a whole wave or any multiple of a whole wave.

Interference Colours (*Light*). Transparent laminæ of any material whatever exhibit colour if they are thin enough. This is due to the fact that some light is reflected from each surface; hence the part reflected from the second surface, having farther to go, is retarded with respect to the part reflected from the first surface, so that the two may strengthen or weaken each other according to the phase difference introduced. Such colours occur frequently in nature. Instances are soap bubbles, mother-of-pearl, very old glass articles, peacocks' feathers, and the plumage of many birds. These colours may be distinguished from absorption colours by the fact that the tint varies as the position of the observer changes.

Interference Fringes (*Light*). When two spherical waves diverge from closely adjacent point sources (or from two narrow parallel slits which are really rows of point sources), then in the space they mutually traverse there will be points at which they destroy each other by interference, and other points at which they reinforce each other. When a small portion of the wave front is received on a screen or the retina, the result is a series of bright or dark lines known as INTERFERENCE FRINGES. The distance between the lines varies with the wave length, hence monochromatic light is necessary for good definition, white light giving a series of superposed fringes of the various colours, and thus exhibiting rainbow tints. Such fringes can be produced in many ways—for instance, by Fresnel's bi-prism (*q.v.*)—and may often be observed by merely looking at a lamp filament through a pocket handkerchief or through the eyelashes.

Interlace (*Textile Manufac.*) This relates to the crossing of warp and weft, the order of the interlacing in a weave prescribing the structure of the cloth.

Intermat (*Textile Manufac.*) The term applied to the felting or shrinking of cloths, the fibres intermatting or felting together.

Intermediate Part. The term "intermediate" is applied in engineering to a wheel, shaft, cylinder, etc., which lies between and is connected to two similar parts.

Intermittent Downward Filtration. *See* FILTRATION, *and under* SANITATION.

Internal Characteristic (*Elect. Eng.*) A curve showing the relation between the current and the electromotive force in the armature of a dynamo. *See also* DYNAMO.

Internal Compensation (*Chem.*) *See* STEREOISOMERISM.

Internal Flue (*Eng.*) A flue running through a boiler so as to be surrounded entirely by water.

Internal Forces. Forces acting between different parts of the same body, *e.g.* stresses. *See* INTERNAL STRESS.

Internally Fired Boiler (*Eng.*) A boiler whose firebox or furnace is inside the boiler and surrounded by water.

Internal Mitre (*Build.*) The intersection of two mouldings forming an angle of less than 180°.

Internal Resistance (*Elect.*) The resistance which a current generator of any kind itself possesses, and which cannot be varied, as distinguished from the external resistance, which may have any value. The sum of the two makes up the total resistance of the circuit.

Internal Screw (*Eng.*) A screw cut on the inside surface of a hollow cylinder (*e.g.* a nut). Also called a female thread.

Internal Stress (*Eng.*) Strictly, all stresses are internal in their nature; but the term is especially applied to stresses in a piece of material which are not due to the load or other applied forces, but to contraction or some similar fault due to bad design or construction.

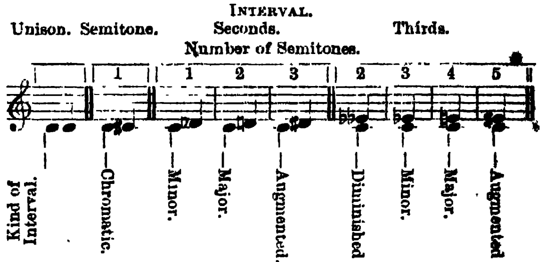
Internal Work (*Phys.*) Whenever a substance alters its volume in consequence of a heat change in it, some work must be done by or done against external pressure, and therefore it is convenient to distinguish between the heat actually given out or absorbed by the substance and corresponding to internal work, and the portion equivalent to the external work done. For instance, about 537 heat units are required to change unit mass of water at 100° to steam at 100°, and of these about 40 are expended against atmospheric pressure, the remainder being actually required for the change of state, or internal work.

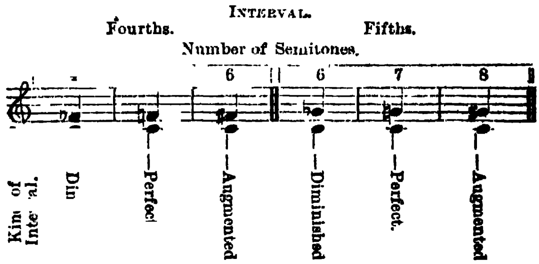
Interrupted Cadence (*Music*). *See* CADENCE.

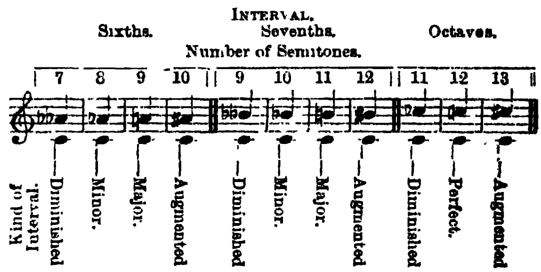
Intersection Theory (*Textile Manufac.*) The theory of cloth construction determined by the number of intersections or interlacings between warp and weft yarns and their relative diameters.

Inter-Tie (*Carp. and Join.*) The intermediate horizontal timber forming the tie in a trussed partition.

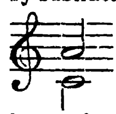
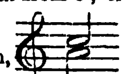
Interval (*Music*). The difference in pitch between any two sounds; scientifically, the ratio between the frequencies of two notes. In music, intervals are reckoned from the lower sound upwards, including both notes, and classed according to the number of alphabetical letters included. Thus C to G is a fifth, as it includes the letters c, d, e, f, g. Intervals exceeding an octave are called compound intervals, and with the exception of the ninth, eleventh, and thirteenth are for harmonic purposes reduced to simple intervals by subtracting seven and treated as that simple interval; *e.g.* a twelfth is treated as a fifth, or a fifteenth (double octave) as an octave or eighth. Intervals are subdivided into different classes according to the number of semitones contained: seconds, thirds, sixths, and sevenths are called major and minor; fourths, fifths, and octaves, perfect. Intervals a semitone less than perfect or less than minor are called diminished, and those a semitone greater than perfect or major are called augmented. The following table gives the intervals within an octave and the number of semitones contained in each. Note that in each case the interval, as stated above, is counted according to the alphabetical letters contained, not according to the number of semitones contained; *e.g.* C to G♮ is a fifth, whilst C to F♯ is a fourth, although in each case the number of semitones contained is six.







When an interval is turned upside down it is said to be "inverted." The inversion may easily be found by subtracting the interval from 9; thus:

 is a major sixth,  (the inversion) is a minor third. By inversion perfect intervals remain perfect, major become minor, minor become major, augmented become diminished, diminished become augmented.

Intrados. *See* ARCH.

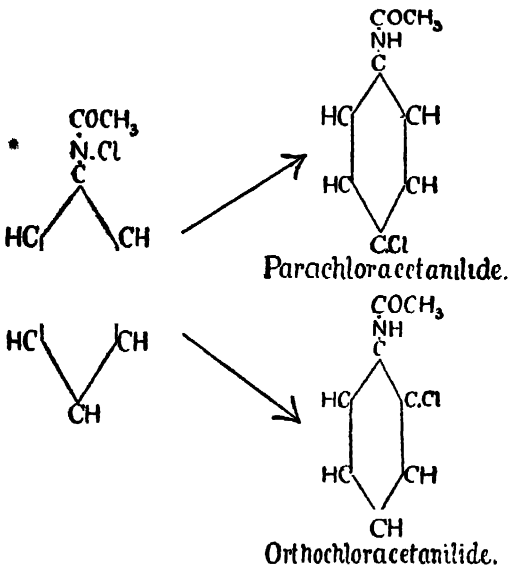
Intramercurial Planets (*Astron.*) Planets which may possibly revolve round the sun in orbits inside that of Mercury.

Intramolecular Change. The name given to a kind of reaction in which the atoms which compose the molecule of certain compounds undergo a rearrangement and produce a new compound. This kind of change can be brought about in many ways,

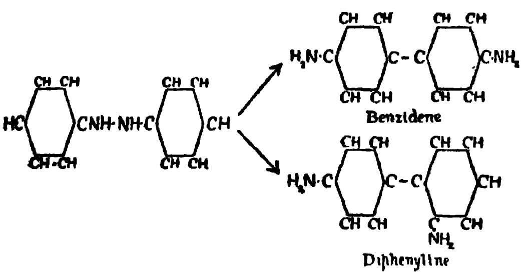
as the following examples show: (1) Ammonium cyanate is transformed into urea on evaporating its aqueous solution on the water bath:

$$N \vdots C . ONH_4 = CO\langle^{NH_2}_{NH_2}.$$

(2) Hydrazobenzene is transformed by acids, even in the cold, into benzidine and a small quantity of diphenylene:



(3) Phenylacetyl nitrogen chloride is transformed, on standing in glacial acetic acid solution, into parachloracetanilide and a small quantity of orthochloracetanilide:



(4) Nitrous acid changes oleic acid into elaidic acid (*q.v.*) It also changes maleic acid into fumaric acid:

$$\begin{array}{ccc} COOH.C.H & & COOH.C.H \\ \| & = & \| \\ COOH.C.H & & H.C.COOH \end{array}$$

Some of the alkaloids undergo intramolecular rearrangement to a remarkable extent: thus cinchonine forms the isomeric alkaloids cinchonicine, cinchonidine, allocinchonine.

Intrusive Rocks (*Geol.*) Eruptive rocks which have made their way, while in a fluid state, upward and outward from deep seated sources (presumedly in connection with volcanic foci), and which have consolidated somewhere below the surface. The great majority of intrusive rocks *replace* their own volume of the rock they invade, *i.e.* they do not *displace* it. Intrusive rocks may conveniently be distinguished in accordance with the position below the surface at which consolidation took place, as PLUTONIC, in the case of the deeper seated rocks, and TRAPPEAN for the remainder.

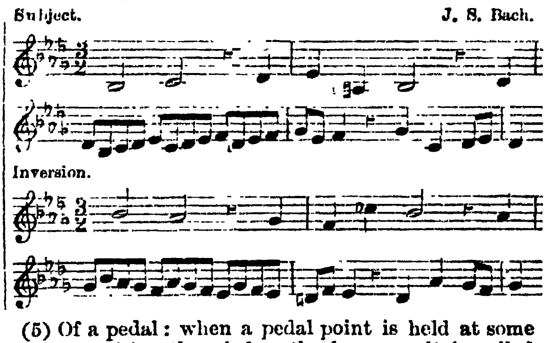
Inulin (*Chem.*), $(C_6H_{10}O_5)_n$. A white crystalline solid which occurs in many plants, *e.g.* in dahlia tubers, in chicory, etc. It is coloured yellow by iodine. On hydrolysis with water containing a trace of sulphuric acid, it yields pure lævulose.

Invected (*Her.*) A partition line formed by semicircular indentations, the converse of engrailed. *See under* HERALDRY.

Inverse Square Law (*Phys.*) Most physical phenomena (electric and magnetic forces, various forms of radiation, etc.) are observed to decrease in amount as we recede from the source or point from which the effect proceeds; if by doubling the distance the effect fall to one quarter of its previous value, the phenomenon is said to follow the INVERSE SQUARE LAW. Thus, if the amount of force (*e.g.* electric or magnetic attraction) at a given point be f, and the distance of the point from the source or origin of the force be r, the law is expressed by the equation $f=\frac{k}{r^2}$, k being a constant.

Inversion (*Chem.*) A name given to the change which occurs when cane sugar is treated with dilute acids. Cane sugar is dextrorotatory. After warming with very dilute sulphuric acid it is changed to a mixture of equal quantities of dextrose and lævulose, of which the latter is more strongly lævorotatory than the former is dextrorotatory. Hence the product is lævorotatory. This change in the direction of rotation gave the name Inversion to the process.

—— (*Music*). (1) Of Intervals (*see* INTERVAL). (2) Of a chord: when any note other than the Root is in the Bass or lowest part, a chord is said to be inverted. (3) Of Counterpoint: when the lower part is placed above the upper in Double Counterpoint, or *vice versâ*. (4) Of a Fugue subject: when the subject is given in contrary motion, thus:



(5) Of a pedal: when a pedal point is held at some other position than below the harmony it is called an inverted pedal.

Inversion of Images (*Elect.*) An application of the mathematical theory of inversion to the solution of problems on electrostatics. When any one problem is solved, the solution of another may be deduced by a purely geometrical process.

Inversion, Thermoelectric (*Elect.*) If one junction of a thermoelectric couple be kept at 0° C. and the other varied in temperature, there will usually be some point at which the E.M.F. becomes zero and then reverses its direction. For instance, with iron and copper the temperature of inversion would be 550° C. More generally, for any two metals

forming a thermo-couple, there is usually some temperature, called the neutral temperature, such that there is no E.M.F. in the circuit when the mean temperature of the junctions is equal to the neutral temperature. When the mean value is less than this, the E.M.F. is in one direction, and in the opposite direction when the mean value is greater. For copper and iron the neutral temperature is 275° C.

Invertase *or* **Invertin** (*Chem.*) A widespread enzyme. It occurs in brewers' yeast; in some moulds and bacteria; in the plants yielding cane sugar; in the liver and intestines of man. The process of extraction from yeast is complex and long. In outline it is as follows: Yeast is treated with strong alcohol, and the *residue* with chloroform water; the latter is filtered into absolute alcohol, and the precipitate dried *in vacuo* over sulphuric acid. The product still contains ash, which can only be removed by an elaborate process. It is a light white powder, and its importance lies in its power of inverting cane sugar. *See* INVERSION. Traces of acid promote its action, while traces of alkali retard its action. Its optimum temperature is about 50° C.

Inverted Arc (*Elect. Eng.*) An arc light having a conical reflector fixed beneath it, so as to throw the light upward. Used in a room with a flat ceiling, it produces very uniform illumination, free from shadows, and is suitable therefore for workshops, drawing offices, and many other purposes.

Inverted Arch (*Build.*) An arch built (near the footings) upside down to distribute the weight of piers, etc., over a greater area.

Inverted Commas. Commas placed thus " " to denote that the matter is quoted; also to denote the title of a book, etc.

Invert Sugar (*Chem.*) The mixture of dextrose and lævulose obtained on inversion of cane sugar. *See* INVERSION.

Involucre (*Botany*). The investment of overlapping scales or bracts on the underside of the capitulum or inflorescence of the *Compositæ*. A similar, but less crowded, involucre occurs in the *Umbelliferæ*, at the base of a main branch of the umbel.

Involute. If a cord wrapped round a curved surface be unwound (the unwound portion being kept tight), its free end will describe a plane curve, termed the INVOLUTE of the first curve; the original curve is termed the EVOLUTE of the curve generated by the end of the cord. If the cord be unwound from a circle, the curve obtained is termed the INVOLUTE OF THE CIRCLE.

Involute Teeth. Wheel teeth whose curves are formed by the involutes (*q.v.*) of a circle. In such teeth, both the root and point of the teeth form parts of one continuous curve. By reason of this property the distance between the axles of two gearing wheels with involute teeth can be varied without interfering with the smoothness of action of the teeth. Such wheels are used in rolling mills, etc., where the distance between the axles is apt to vary somewhat. No other form of wheel teeth will allow of this variation.

Iodates (*Chem.*) Salts of iodic acid. Sodium iodate occurs naturally along with sodium nitrate. *See under* IODINE. Potassium iodate, KIO_3, is obtained by the action of caustic potash solution on iodine, $3I_2 + 6KOH = 5KI + KIO_3 + 3H_2O$. As the iodate is much less soluble than the iodide, it can be separated by repeated crystallisation. The salt may also be obtained by heating either iodine or potassium iodide with potassium chlorate. On heating, it loses oxygen and some iodine, forming potassium iodide and some oxide. It combines with iodic acid to form acid salts. Silver iodate, $AgIO_3$, is obtained by double decomposition between silver nitrate and potassium iodate, $AgNO_3 + KIO_3 = AgIO_3 + KNO_3$. Stas used this salt in one of his numerous determinations of the atomic weight of silver. On heating, it loses oxygen and some iodine, leaving a residue of silver iodide and some silver.

Iodic Acid (*Chem.*), HIO_3. A heavy white crystalline solid, soluble in water, insoluble in alcohol. Kept at 200°, it loses water and forms the anhydride iodine pentoxide. It behaves as a strong oxidising agent; *e.g.* it oxidises hydriodic acid to water and iodine, $HIO_3 + 5HI = 3H_2O + 3I_2$. Used as a test for morphine, which liberates iodine from it. It is prepared by heating iodine with strong nitric acid, evaporating to dryness, heating the residue for some time at 200° to expel all nitric acid, and crystallising from water.

Iodine, I. (*Chem.*) *Atomic weight*, 127. Dark grey lustrous solid; melts at 114°; boils at 184°. The vapour is blue when pure, reddish violet when mixed with air; below 700° the molecule is diatomic; at 1700°, monatomic. Sp. gr. of iodine = 5. It is slightly soluble in water, forming brownish solution; very soluble in potassium iodide solution, giving a red solution; very soluble in carbon disulphide and chloroform, giving a violet solution. Strong solutions of iodine in carbon disulphide do not transmit the visible and ultra violet rays of the spectrum, but do transmit rays of greater wave length than these (so called "heat rays"). It unites with many elements forming iodides; *e.g.* hydrogen (*see* HYDRIODIC ACID), mercury (*q.v.*), iron (*q.v.*) With caustic soda or potash it forms potassium iodide and iodate, $3I_2 + 6KOH = 5KI + KIO_3 + 3H_2O$. With ammonia it forms nitrogen iodide (*q.v.*) Strong nitric acid oxidises it to iodic acid (*q.v.*) With starch paste it gives a deep blue colour: this reaction supplies a common test for the presence of iodine. Iodine occurs in sea water and in sea plants and animals, hence it is present in sponges and in cod liver oil; in crude Chile saltpetre; combined with certain metals, *e.g.* silver; in certain rather rare ores; in some mineral springs, *e.g.* one at Woodhall Spa near Lincoln is famous for the free iodine it contains; in the thyroid gland in man. The world's production of iodine is practically under the control of a syndicate which owns nearly all the South American and a great part of the Scotch iodine manufacture. The French iodine makers are bound by the syndicate only to produce for home consumption. Most iodine is extracted from Chili saltpetre, $NaNO_3$, which contains sodium iodate, $NaIO_3$, as impurity. On crystallising the solution of the crude nitrate, sodium nitrate separates out, while the iodate remains in solution. From the solution sodium hydrogen sulphite precipitates the iodine, $2NaIO_3 + 5NaHSO_3 = 3NaHSO_4 + 2Na_2SO_4 + 2H_2O + I_2$. Iodine is also obtained from seaweed in Scotland and in France. The weed (deep-sea weed) is either carefully burned or is simply extracted with water to dissolve out the soluble salts. In the former case the ash is extracted with water. The solution in both cases is concentrated, when the less soluble salts (sulphates, etc.) separate out. The mother liquor, which contains the iodides, is distilled with manganese dioxide and

sulphuric acid in quantity just insufficient to liberate all the iodine. All iodides treated in this way give up their iodine, $2KI + MnO_2 + 3H_2SO_4 = 2KHSO_4 + MnSO_4 + 2H_2O + I_2$. Iodine is purified by subliming. Pure iodine is obtained by dissolving sublimed iodine in potassium iodide solution, precipitating it by water, distilling in steam, drying over calcium nitrate, and redistilling over barium oxide.

Iodine Absorption *or* **Iodine Value** (*Chem.*) Unsaturated fatty acids have the property of uniting directly with iodine: so also have their glycerides (fats). The amount of iodine which combines with 100 parts of the fatty acid or fat is called the iodine absorption or iodine value of the fat. The acid or fat is weighed and dissolved in chloroform and an excess of Hübl's reagent added, the amount added being known. Hübl's reagent is made by dissolving 25 grams of iodine in 500 cc. of 95 per cent. alcohol and 30 grams of mercuric chloride in a like amount of the same alcohol, and mixing the two solutions. The excess of iodine is found by titration with a standard solution of sodium thiosulphate: 100 parts of oleic acid require 90 parts of iodine, and 100 parts of olein require 86·2 parts; thus if the only unsaturated acid or fat present were oleic acid or olein, its amount is readily found. The iodine value of a fat can always be found; but if the fat is a mixture of glycerides of unsaturated fatty acids, the amount of each constituent can only be calculated in simple cases. The process is useful in estimating the amount of olein in butter, as olein is the only unsaturated fat present in butter.

Iodine Pentoxide (*Chem.*), I_2O_5. A white solid obtained by heating iodic acid at 200°; at 300° it decomposes into iodine and oxygen. It dissolves in water, forming iodic acid.

Iodobenzene, C_6H_5I (*Phenyliodide*). A colourless liquid: boils at 188°. Obtained by heating benzene, iodine, and iodic acid together at 200°. The iodic acid converts the hydriodic acid liberated by the action of the iodine into iodine again:

$$5C_6H_6 + 4I + HIO_3 = 5C_6H_5I + 3H_2O.$$

Also it is prepared by diazotising aniline with hydrochloric acid and sodium nitrite (*see* DIAZO COMPOUNDS), and adding strong potassium iodide solution and warming. Iodobenzene unites with dry chlorine in chloroform solution, forming a dichloride—a yellow crystalline solid, $C_6H_5ICl_2$, in which iodine is *trivalent*. The iodobenzene dichloride, when treated with caustic soda solution, is converted into IODOSOBENZENE,

$$C_6H_5ICl_2 + 2NaOH = C_6H_5IO + 2KCl + H_2O,$$

which explodes about 200°, and liberates iodine from a solution of potassium iodide acidified with acetic acid. It also acts as a base, forming salts which may be regarded as derived from $C_6H_5I\langle^{OH}_{OH}$, *e.g.* iodosobenzene acetate, $C_6H_5I\langle^{OOCCH_3}_{OOCCH_3}$. When iodosobenzene is heated alone, or heated in steam, or preferably oxidised with hypochlorous acid, iodoxybenzene, $C_6H_5IO_2$, is obtained: it forms colourless crystals which explode at about 230°. When a mixture of iodosobenzene and iodoxybenzene is shaken with moist silver oxide, a solution of DIPHENYLIODONIUM HYDROXIDE is obtained:

$$C_6H_5IO + C_6H_5IO_2 + AgOH = (C_6H_5)_2IOH + AgIO_3.$$

This substance behaves like a strong base, and forms salts with acids. Thus the chloride, bromide, iodide, nitrate, carbonate, etc., are known. The iodide $(C_6H_5)_2I.I$ is polymeric with iodobenzene. The iodonium compounds may be regarded as derivatives of the unknown compound IH_2OH, which is called iodonium.

Iodoform (*Chem.*), CHI_3. Shining yellow scales; melts at 120°; characteristic odour; insoluble in water; soluble in alcohol, ether, chloroform; used as an antiseptic and disinfectant for sores and wounds, its action being probably due to liberation of iodine, as the unchanged substance does not appear to be an antiseptic. Hydriodic acid converts it into methylene iodide, $CHI_3 + HI = CH_2I_2 + I_2$. The zinc-copper couple reduces it to acetylene, as does also finely divided silver. It can be distilled in steam. It is obtained by warming alcohol with a solution of sodium carbonate to about 80°, and gradually adding iodine; when cool, the clear liquid is separated from the precipitated iodoform, and as it contains sodium iodide, more alcohol and carbonate are added and chlorine passed in to liberate the iodine, when a further quantity of iodoform is obtained. It is also obtained electrolytically: the positive pole of a battery dips into a solution of sodium carbonate, potassium iodide, and alcohol, contained in a porous cell, and the negative pole into a solution of caustic soda, which surrounds the porous cell. Many other substances besides alcohol give iodoform when warmed with sodium carbonate solution and iodine, *e.g.* the higher homologues of alcohol (normal alcohols), also aldehyde and its homologues, acetone, etc. The production of iodoform from alcohol serves as a delicate test for the latter, of course only in the absence of the other substances named.

Iodol *or* **Tetraiodopyrrole** (*Chem.*) $\begin{array}{l}CI=CI\\ \ \vert\qquad\ \ \rangle NH.\\ CI=CI\end{array}$ Brownish yellow prisms; melts at 140°, with decomposition; no smell; insoluble in water; soluble in hot alcohol; soluble in ether; prepared by the action of iodine on pyrrole (*q.v.*); preferably in presence of an alkali. It is used as an antiseptic in place of iodoform, as it has no smell; its action is the same.

Iodonium Compounds (*Chem.*) *See* IODOBENZENE.

Iodosobenzene (*Chem.*) *See* IODOBENZENE.

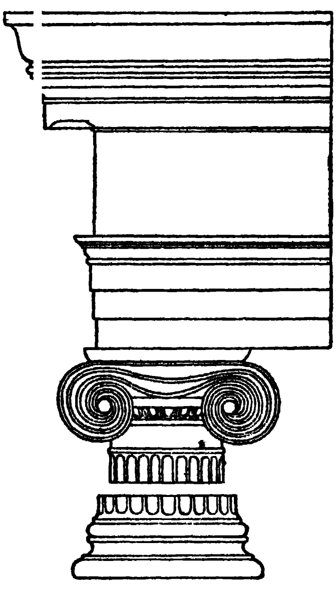
Iolite (*Min.*) Silicate of aluminium, magnesium, and iron, $H_2O.4(Mg.FeO).4Al_2O_3.10SiO_2$. Silica $= 49·4$, alumina $= 33·9$, magnesia $= 8·8$, ferrous oxide $=$ 7·9 per cent. Orthorhombic, in blue crystals, often dichroic (whence the synonym DICHROITE). More easily fused than Quartz, softer than Sapphire. It is used as a gem under the name Saphir d'eau. From Norway, France, Ireland, Bavaria, etc.

Ion (*Elect.*) A term introduced by Faraday to denote the current carriers in electrolysis. Ions include ANIONS and CATIONS, which appear at the anode and cathode respectively. The term has since come to signify a portion of ordinary matter associated with a definite electric charge, either positive or negative; for instance, a solution of common salt in water probably consists partly of unaltered molecules and partly of free sodium and chlorine atoms, carrying positive and negative charges respectively. These latter are the ions, and their number increases with the dilution. Their presence confers conductivity on the solution, and if the dissolved substance does not ionise, it will not conduct. Every

monad atom in electrolysis appears to carry exactly the same charge, and every dyad atom twice that charge, and so on. Whilst in this state the ordinary chemical properties of the substance are in abeyance, only becoming apparent when the charge is removed. *See also* IONISATION; IONS, VELOCITY OF; *and* IONS, MIGRATION OF.

Ionian (*Music*). *See* MODES.

Ionic Order (*Architect.*) This order was adopted by the Greeks in Ionia during the fifth century B.C. It is less sturdy, less severe, and treated with greater freedom than the Doric. For description *see* ARCHITECTURE, ORDERS OF.



IONIC ORDER.

Ionic Velocity (*Elect.*) *See* IONS, VELOCITY OF.

Ionisation (*Elect.*) The dissociation of a compound body into ions—that is, into atoms or molecular groups carrying definite electric charges. The phenomena are most striking in the case of electrolysis, and the great value of water as a solvent for electrolytes appears to depend upon its power of facilitating ionisation. Although gases are among the best of non-conductors at ordinary pressures, they may be ionised, and will then conduct more or less. This may be done in various ways, amongst others by ultra-violet light, by Röntgen rays, or by the radiations from radium and other radio-active substances. *See also* ION.

Ionisation Coefficient (*Elect.*) The fraction of the total number of dissolved molecules which exist in the condition of ions. Thus if N be the total number of molecules of the dissolved substance present in the solution, and n the number dissociated or broken up into ions, the ionisation coefficient is $\frac{n}{N}$. This quantity is also termed the DISSOCIATION COEFFICIENT.

Ionone (*Chem.*) *See* TERPENES.

Ions, Migration of (*Elect.*) During electrolysis the strength of a solution does not remain uniform, but becomes greater near one electrode than at the other. This is still the case when all allowance is made for the influence of secondary reactions, and the observed fact first suggested the idea that different ions travel with different velocities under the same potential difference. *See also* ION, IONISATION, *etc.*

——, Velocity of (*Elect.*) The charged ions of an electrolyte during electrolysis move in opposite directions towards the electrodes with velocities which depend upon the nature of the ion and upon the difference of potential per unit length. Hydrogen ions move the fastest, at the rate of about ·0035 centimetres per second, under a P.D. of 1 volt per centimetre. These velocities may be calculated by measuring the change of concentration at the electrodes and also the electric conductivity. In some cases the motion may be made visible, and the direct measurements thus obtained agree very well with the calculated values.

Ipecacuanha. The roots of this Brazilian plant, *Uragoga ipecacuanha* (order, *Rubiaceæ*), furnish the ringed Ipecacuanha, while the striated variety is the produce of a closely allied genus.

Ipomœa (*Botany*). A genus of the order *Convolvulaceæ*, consisting of climbing plants chiefly. The sweet potato is the tuberous root of *I. batatas*, and the swollen roots of *I. purga* yield JALAP.

Iridium (*Min.*) This rare metal occurs native in cubic crystals, or more often in silvery grains. It also occurs in the alloy IRIDOSMINE with osmium. Its hardness is 6—7, and its specific gravity about 22·7. Found chiefly in the Urals.

——, Ir. (*Chem.*) Atomic weight, 193. A shining white metal; next to osmium, the heaviest known element; melts at over 2,000°—that is, higher than platinum, and the oxyhydrogen flame only melts it with difficulty. In fine state of division it is dissolved by aqua regia, but not after it has been melted. It occurs naturally along with platinum. After the platinum has been removed from the ore by aqua regia there remains a shining scaly residue which consists of an alloy known as OSMIRIDIUM. This alloy consists chiefly of iridium and osmium, with small amounts of the other platinum metals and iron or copper. This alloy is heated with common salt in a stream of moist chlorine, when most of the osmium volatilises, and the iridium and other metals form soluble double chlorides with the salt. The solution of these is treated while boiling with sulphuretted hydrogen; the other metals are precipitated as sulphides first, and the gas is stopped as soon as the orange yellow iridium sulphide begins to appear. The liquid is filtered, evaporated, and the double chloride $6NaCl . IrCl_4 24H_2O$ recrystallised. This is converted into the ammonium salt, which is less soluble, and on heating yields finely divided iridium. It can be made coherent by heating to whiteness and pressing. *Uses:* The standard metre is an alloy of 10 per cent. iridium and 90 per cent. platinum. Vessels of platinum with 25 to 30 per cent. of iridium are not attacked by aqua regia. It is also used in making iridium pointed pens. Its salts resemble those of platinum to some extent, and are unimportant.

Iridosmine (*Min.*) *See* IRIDIUM (*Min.*)

Iris (*Botany*). A genus of the order *Iridaceæ* known as "Flags." The violet scented rhizomes of *Iris florentina* (Orris root) are used in perfumery.

—— (*Zool.*) The coloured portion of the eye, formed by a continuation of the choroid coat to form a circular curtain to the front of the eye. The opening in the centre (the pupil) becomes smaller or larger under the varying intensity of light.

Iron, Fe. Atomic weight, 56. Pure iron is a soft white metal not possessing any of the useful properties of steel, wrought iron, or cast iron; it melts about 1600°; that is, higher than any of the useful forms of iron. When pure iron is heated to near its

melting point and allowed to cool slowly, a remarkable and sudden decrease in the rate of cooling occurs at a temperature of about 860°. Except for this, the rate of cooling is very regular. This retardation of cooling can only be due to a liberation of heat in the iron itself, and the only feasible explanation of such behaviour is that the iron at this point changes from one state to another. The phenomenon of heat liberation is called recalescence, and the form of iron above the point of recalescence is called β-ferrite; that below, α-ferrite. These two forms of iron play an important part in the hardening of steel. Above the recalescent point iron is not magnetic; below this point iron is magnetic. Pure iron is easily oxidised in air, the change occurring rapidly at high temperatures, very slowly at ordinary temperatures, unless the iron is in a very fine state of division, when it is spontaneously inflammable (pyrophoric). In dry air, ferric oxide, Fe_2O_3, is formed on complete oxidation; but in moist air, hydrated ferric oxide is formed, $Fe_2O_3xH_2O$, where the limit of x is 3. Pure iron is readily attacked by acids, forming ferrous salts. The action of very strong nitric acid is peculiar. This acid produces a superficial change, probably oxidising the surface to Fe_3O_4. Iron which has been plunged into very strong nitric acid is not attacked by dilute nitric acid, nor does it precipitate copper from solutions of copper salts. In this state iron is said to be "passive." If the surface of such iron be removed, as by filing, it loses its passivity, and again dissolves in dilute nitric acid and precipitates copper. Other oxidising agents besides nitric acid, *e.g.* chromic acid, can produce passivity. Pure iron can be obtained by reducing the pure ferric oxide in hydrogen, when the metal is obtained pyrophoric at low temperatures, and non-pyrophoric at high temperatures; also by electrolysis of a solution of ferrous sulphate. It is doubtful if iron occurs free on earth except in the form of meteorites. It occurs in combination in the hæmoglobin of the blood and in the green parts of plants. The chief ores of iron are, magnetite, Fe_3O_4; red hæmatite, Fe_2O_3; brown hæmatite, Fe_2O_3, combined with more or less water; spathic iron ore, $FeCO_3$; clay ironstone, which is $FeCO_3$ associated with clay; and black band ironstone, which is $FeCO_3$ associated with carbonaceous matter. Iron also occurs combined with sulphur as iron pyrites, FeS_2, which is not used as an ore of iron, but is largely used in the manufacture of sulphuric acid. The following is a brief description of the extraction of iron from its ores: it applies to clay ironstone or black band ironstone, and would be modified for other ores. The operation is carried out in a blast furnace. *See* FURNACES. Before the ore is put in the furnace it is calcined; that is, heated to drive off carbon dioxide and water, and to render it more porous. During this process the iron is changed from the form of carbonate to that of the oxides Fe_3O_4 and Fe_2O_3. Along with the ore there is also put into the furnace coke and limestone, the former serving as fuel and the latter as a flux, which will combine with the silica and aluminium oxide of the ore to form a fusible double silicate of calcium and aluminium which constitutes the slag. The chemical composition of the ore and the character of the product required determine the proportions of coke and limestone to be added to the ore, and all three are weighed out and introduced into the furnace at the top by means of the cup and cone arrangement. A blast of air heated to from 300 to 600° by being drawn through chambers heated to redness by the waste gases of the furnace is blown into the furnace under a pressure of 4 to 5 lb. per square inch through a number of openings in the furnace a little above the place where the slag is drawn off. The changes which occur in the furnace are somewhat as follows: The oxygen of the air forms carbon monoxide with the excess of carbon contained in the coke, and the carbon monoxide reduces the oxide of iron to the metal, being converted in the process to carbon dioxide. This is the predominant change in the higher regions of the furnace. Lower down, where the temperature is higher, the reducing action of carbon itself plays a part, reducing oxide of iron to the metal, and forming probably carbon dioxide. But at high temperatures iron can take up oxygen from both oxides of carbon, reproducing iron oxide. Finally, carbon dioxide can combine with carbon to form carbon monoxide. Until the hottest part of the furnace is reached the result produced is the difference between the opposing reactions just described, the reducing reactions preponderating. Coke and clay both contain small quantities of sodium and potassium, and these metals, in the form of carbonate, are converted by nitrogen in presence of carbon at a high temperature into potassium cyanide, which is a powerful reducing agent. This compound is produced in the furnace, and reduces the remaining portions of iron oxide to the metal. The iron which now melts dissolves carbon, silicon, manganese, phosphorus, and sulphur, the last two being present in traces only, and sinks to the bottom of the furnace, whence it is withdrawn from time to time. The lime of the limestone and the aluminium oxide of the clay unite with the silica forming the slag, which melts and floats above the iron and is withdrawn at much more frequent intervals than the iron. The product of the blast furnace is called PIG IRON or CAST IRON. Various grades of pig iron are produced, depending on the ratio of ore to fuel, and therefore on the temperature. Grey cast iron is produced when the ratio (called the burden of the furnace) is low, white cast iron when the burden is high. The chief differences between grey and white cast iron are: Grey cast iron contains most of its carbon free; it is softer than white cast iron. On melting, it passes at once to the fluid state, while white cast iron becomes pasty, and is never so fluid; also grey cast iron melts at a higher temperature. Grey pig iron is used for castings; white in making steel. Varieties of cast iron containing much manganese are called spiegeleisen or ferromanganese, and are used in steel making. WROUGHT IRON is the purest form of useful iron, and is usually made in this country from grey pig iron by a process known as the puddling process. This process is carried out in a reverberatory furnace (*see* FURNACES) having a cast iron bottom, covered with a slag technically called "bulldog" (it is a mixture of ferrous silicate and ferric oxide, obtained by roasting the slag—"tap cinder"—of a previous operation), and the scale beaten out of the wrought iron when it is hammered under the steam hammer. The pig iron is placed in the furnace with slag from a previous operation. Part of the impurities are burned away during the melting. When the iron has melted, it becomes covered with a layer of slag, which prevents further oxidation; it is well stirred with iron bars by the puddler, and the carbon is removed from the iron by union with ferric oxide from the furnace bed. The metal is now made purer, and melts at a higher temperature, so that it is only pasty at this stage of the process. It is accordingly made into "blooms," and removed from the furnace to the steam hammer,

where the slag is beaten out of it; after this it is rolled. A better quality wrought iron is produced by cutting this product into bars, heating them, and again rolling them; and this process may be repeated. *See* FAGOTING. STEEL is intermediate, as to the amount of carbon it contains, between cast iron and wrought iron, so that it can be made from a very pure iron by addition of carbon, or from an iron rich in carbon by removing some of this element. The cementation process is an example of the first method. In this process bars of wrought iron are heated in contact with carbon and out of contact with air to about the melting point of copper. The extent of carburisation that takes place depends on the time the carbon is left in contact with the iron; if the time is short, the iron is only case hardened. HARVEYISED STEEL is produced by case hardening, and then suddenly cooling the metal by ice cold water, directed as a spray on the carburised surface. When the iron has been exposed the required time to the action of the carbon, the bars are melted to obtain a homogeneous product, and then cast. Very high quality steel is made in this way. The carbon probably enters the iron partly by a process of diffusion between the two solids and partly through the agency of carbon monoxide. In other processes for steel making a combination of the two methods mentioned above is adopted, cast iron being deprived of all, or nearly all, its carbon, and then the requisite amount of carbon added to it, usually in the form of high carbon pig iron containing manganese or silicon (spiegeleisen or ferrosilicon). OPEN HEARTH PROCESS: A regenerative furnace (*see* FURNACES) is employed. If the iron to be used is nearly free from phosphorus, the hearth is of silica; if phosphorus is present to an appreciable amount, it is of calcined dolomite (*q.v.*) In the SIEMENS-MARTIN PROCESS the charge consists of pig iron, scrap iron and steel, and iron oxide ores. The ores are added gradually after the melting of the pig and scrap. Some of the impurities are oxidised during the melting, especially manganese and silicon; after melting, most of the carbon is removed by the iron oxide ores as carbon monoxide. The metal now contains too little carbon, and the requisite amount of carbon is added in the form of spiegeleisen and ferrosilicon (cast iron rich in silicon). Low carbon steels are usually made in this way. The Siemens process differs from the above in that ore is not used. BESSEMER PROCESS: In this process a special apparatus known as the Bessemer converter is used. The converter is an iron vessel with a lining of gannister (*q.v.*); the bottom is perforated with holes which open into a box supplied with a blast of air when the converter is working, of sufficient pressure to keep the molten charge from entering the holes. The blast is supplied to the box by a pipe which communicates with one of the two trunnions which support the converter, this trunnion being hollow, while the other is solid. The trunnions allow of the converter being turned through an angle of 180° for filling and emptying, and through the hollow trunnion the blast is supplied to the converter. Melted pig iron is brought into the converter while on its side, the blast is turned on, and the converter brought into the vertical position. Silicon and manganese are first oxidised by the air blast, then the carbon, the latter stage being marked by issue of flame from the mouth of the converter. This flame is due to carbon monoxide; and when it "drops" the blast is turned off as the oxidation of carbon is at an end. The metal now contains too little carbon, and the proper quantity of spiegeleisen is added to the converter. The process is now ended, and the charge is poured into ladles and cast. Converters with gannister linings will not remove phosphorus from pig iron; so that pig iron containing more than a trace of phosphorus cannot be used for steel making in such converters. Thomas and Gilchrist introduced a lining of calcined magnesian limestone in place of gannister in the converter for the manufacture of steel from pig iron containing phosphorus. Their process is called the basic Bessemer process, because the strong non-volatile bases calcium oxide and magnesium oxide combine with the acid oxide of phosphorus to form phosphates. To prevent the lining being rapidly used up in this way, lime is added to the charge, and forms, with the phosphoric oxide, a slag of basic calcium phosphate which is a valuable manure. *Varieties of Useful Iron:* Wrought iron contains 99·6 to 99·8 per cent. of iron; it has the highest melting point of all the useful forms of iron; it is soft and fibrous; strongly magnetic, but not retentive of magnetisation; cannot be hardened or tempered; is easily welded; it is malleable and ductile. Steel may contain from about 0·2 per cent. of carbon to 1·5 per cent. Low carbon steels are called MILD STEEL, and approach wrought iron in properties. It melts below wrought iron; is harder and less ductile; more difficultly magnetisable, but once magnetised it is retentive of its magnetism, so that steel is used in making permanent magnets, while wrought iron is used in making electromagnets. The carbon in steel confers upon it the unique property of being hardened and tempered. If steel be heated above the point of recalescence of pure iron, and then suddenly cooled, it becomes hard, high carbon steels becoming so hard that they will cut glass (glass hard). The degree of hardness can be reduced to any desired extent, between certain limits, by again heating the steel to a temperature dependent on the degree of hardness required, but always lower than in hardening, and again cooling. This process is called TEMPERING. Steel which has been heated to a high temperature and slowly cooled is said to be annealed. The chemical and microscopical examination (the latter a branch of the science of metallography) of steel have shown it to consist of various substances, which confer on it its characteristic properties. The more important of these substances are: (1) α- and β-FERRITE. The former is the same as pure iron; the latter is a harder and non-magnetic modification of iron present in steel when it has been heated above the recalescent point of pure iron and suddenly cooled, the carbon in the steel hindering its transformation into α-ferrite. (2) CEMENTITE, a name given to the carbide of iron Fe_3C, which is present in high carbon steel. (3) MARTENSITE, which occurs in the hardest steel and is a solution of iron carbide in iron. (4) PERLITE, which is a mixture of α-ferrite and cementite, containing 0·8 per cent. of carbon. Steel heated above the recalescent point of pure iron may be regarded as a solution of cementite in β-ferrite. The changes that occur as the temperature falls will depend on the rate of cooling and the amount of cementite present. With sufficient cementite and rapid cooling we shall have the hardest steel, consisting of β-ferrite and martensite. If the cooling is slow the iron will revert to α-ferrite; the soft modification and cementite will separate out, and soft steel will result. Between these extremes it is clear many gradations can exist. In the tempering of

hardened steel the metal is heated to such a temperature that changes in the proportions of the constituents mentioned occur in the sense that β-ferrite changes to α-ferrite, and cementite separates out from solution. The working of steel also alters its structure markedly. Several other elements besides carbon have an important influence on the properties of steel. Thus manganese above a certain percentage renders steel non-magnetic; it also retards or prevents the conversion of β- to α-ferrite, and thus makes a hard steel. Chromium in steel confers remarkable properties upon it. "The use of chromium alloyed with iron in making projectiles . . . is now general; they contain from 1·2 to 1·5 per cent. of chromium, and will hold together even when they strike steel plates at a velocity of 2,000 ft. per second" (ROBERTS-AUSTEN). Nickel in steel confers great hardness upon it: Harveyised nickel steel is employed in making armour plates. Cast iron has already been mentioned: it may contain from 2·5 to 4 per cent. of carbon; white cast iron even more. W. H. H.

Iron (*Min.*) This element occurs native in Greenland in some quantity, and very sparingly in Auvergne, Brazil, Ireland, etc. Iron of meteoric origin has been found in many parts of the world. Native iron is cubic, is malleable and ductile, and exhibits all the properties of the artificially reduced metal. Meteoric iron usually contains admixture of other metals.

Iron Cement (*Eng.*) A mixture of iron filings or borings with a very small amount of sal-ammoniac (ammonium chloride). This mixture rusts and hardens into a solid mass, which fills up joints in iron piping, etc., and makes them watertight. *See* RUST JOINT.

Iron Compounds (*Chem.*) (1) FERROUS COMPOUNDS: In these iron is divalent. *Ferrous oxide*, FeO, is a black powder; takes fire in air; readily combines with carbon dioxide; it is prepared by reduction of ferric oxide in hydrogen at 300°, or by heating ferrous oxalate out of contact with air. *Ferrous hydroxide*, $Fe(OH)_2$: A white solid; rapidly oxidises in air, turning first a dirty green colour, then reddish brown, owing to formation of hydrated ferric oxide; it is prepared by mixing air free solutions of caustic soda and ferrous sulphate out of air. *Ferrous chloride*, $FeCl_2$: Forms white crystalline scales when anhydrous, green crystals containing $6H_2O$ when obtained by evaporation of its aqueous solution. Vapour density at low temperature corresponds to formula Fe_2Cl_4, at high temperature to $FeCl_2$. Heated in air it gives Fe_2O_3. Forms double salts with alkali chlorides, *e.g.* $FeCl_2 2NH_4Cl$. Dissolves nitric oxide, forming a dark brown solution. Anhydrous salt, obtained by passing dry hydrogen chloride over heated iron; crystallised salt, obtained by dissolving iron or ferrous sulphide in hydrochloric acid, and crystallising the solution. *Ferrous sulphate*, $FeSO_4$: A white solid obtained by heating the crystallised salt carefully till all water of crystallisation is expelled. Ordinarily met with as green crystals, $FeSO_4 7H_2O$, which are called *green vitriol* or *copperas*; in this form it is isodimorphous with magnesium sulphate. Its solution oxidises on exposure to air, forming hydrated ferric oxide and ferric sulphate; it dissolves nitric oxide, forming a dark brown solution, a property made use of in testing for nitrates. It forms double salts with alkaline sulphates, *e.g.* ferrous ammonium sulphate, $FeSO_4(NH_4)_2SO_4 6H_2O$, which is more stable in air than ferrous sulphate, and is therefore used in standardising solutions of potassium permanganate and dichromate for use in volumetric analysis. Ferrous sulphate is used as a reducing agent, *e.g.* it reduces gold from a solution of gold chloride. It was formerly used in making Nordhausen sulphuric acid by partial roasting and subsequent distillation. It may be obtained by dissolving iron or ferrous sulphide in dilute sulphuric acid, and crystallising the solution. On the large scale iron pyrites, FeS_2, are exposed to air, and moistened with water; rapid oxidation occurs, and from the mass ferrous sulphate can be obtained by extraction with water and crystallising the solution. Ferrous sulphate is largely used in making ink. *Ferrous iodide*, FeI_2: Obtained by heating finely divided iron in iodine vapour out of air; is remarkable as being a dark red brown crystalline solid, other ferrous salts being white. (2) FERRIC COMPOUNDS: In these iron is trivalent. *Ferric oxide*, Fe_2O_3: A reddish brown powder; only soluble in acids with difficulty, after it has been strongly heated; insoluble in water; easily reduced to the metal by heating in hydrogen or carbon monoxide; less easily by heating with carbon. It is obtained by heating the hydroxide and many salts of iron in air. When obtained by heating ferrous sulphate it is used for polishing purposes under the name of jewellers' rouge. It is a common ore of iron (*q.v.*) *Ferric hydroxide*, $Fe(OH)_3$: Obtained as a slimy dark brown precipitate when ammonia is added to a solution of ferric chloride in the cold; on warming, the precipitate becomes granular. When heated it forms ferric oxide. It dissolves in ferric chloride solution, and on submitting this product to dialysis (*q.v.*), it is obtained in a soluble colloidal form. This solution is used in medicine under the name of *dialysed iron*; it does not show the ordinary reactions of iron, and it is precipitated by addition of solutions of salts. Hydrated ferric oxides, containing less water than ferric hydroxide, are formed when iron rusts in moist air. It has the property of fixing colouring matters on fabrics (cotton, linen, etc.), and on this account many ferric salts which are hydrolysed by water, such as the nitrate, acetate, and sulphate, are used as mordants; *e.g.* $Fe(NO_3)_3 + 3H_2O = Fe(OH)_3 + 3HNO_3$. Hydrated oxides of iron are important ores of iron (*q.v.*) *Ferric chloride*, $FeCl_3$: Is a red brown solid with a green lustre when anhydrous; this form is obtained by heating iron in a rapid stream of chlorine. When obtained by evaporating its aqueous solution to the solidifying point, it forms brownish yellow crystals of the composition $FeCl_3 6H_2O$. A solution of ferric chloride can be prepared by dissolving iron in hydrochloric acid, and passing chlorine into the solution, or oxidising the solution with nitric acid, $6FeCl_2 + 6HCl + 2HNO_3 = 6FeCl_3 + 2NO + 4H_2O$; also by dissolving ferric hydroxide in hydrochloric acid. Anhydrous ferric chloride boils at about 280°, and its vapour density corresponds to the formula Fe_2Cl_6 just above its boiling point; at higher temperatures to $FeCl_3$. It is soluble in alcohol; it is used in organic chemistry as a "halogen carrier," *e.g.* nitrobenzene is converted by chlorine in presence of $FeCl_3$ into metachlornitrobenzene. The solution of ferric chloride is partly hydrolysed by water, completely at great dilutions, $FeCl_3 + 3H_2O = Fe(OH)_3 + 3HCl$; so that it always reacts acid to litmus. It is an oxidising agent, *e.g.* $2FeCl_3 + H_2O + H_2SO_3 = H_2SO_4 + 2HCl + 2FeCl_2$. It coagulates albumin. Solutions of ferric chloride in water and in alcohol are used in medicine. *Ferric sulphate*, $Fe_2(SO_4)_3$: A pale yellowish white

solid which dissolves in water plentifully, but slowly. It may be prepared by adding sulphuric acid to ferrous sulphate, and oxidising with nitric acid, $6FeSO_4 + 3H_2SO_4 + 2HNO_3 = 3Fe_2(SO_4)_3 + 2NO + 4H_2O$. It forms alums with the alkali sulphates, *e.g.* $K_2SO_4Fe_2(SO_4)_3 24H_2O$. *Ferric acetate*, $Fe(C_2H_3O_2)_3$: Forms a deep red uncrystallisable solution, which forms an insoluble basic acetate, $Fe(OH)_2(C_2H_3O_2)$, on heating. Use is made of this property in analysis to separate iron from other metals. (3) OTHER COMPOUNDS OF IRON: *Ferrosoferric oxide*, Fe_3O_4: Also called magnetic oxide of iron. Occurs naturally, and is an important ore of iron (*q.v.*) Obtained as a dark brown solid by passing steam over heated iron. As its name implies, it is magnetic. It is formed as a thin layer on iron in Barff's process (*q.v.*) Chemically it behaves as if it were a compound of ferrous and ferric oxides, $Fe_3O_4 = FeO_6Fe_2O_3$. *Sulphides of iron;* Ferrous sulphide, FeS, is obtained as a dark grey solid on heating iron and sulphur together; also as a black precipitate when ammonium sulphide is added to a soluble iron salt. It is this compound which causes the blackening of the teeth and faeces after taking iron. It readily dissolves in acids, forming a ferrous salt, and evolving sulphuretted hydrogen. *Iron disulphide*, FeS_2: Also called Iron Pyrites, or Mundic, when it occurs crystallised in the regular system: Marcasite when it occurs crystallised in the triclinic system. Heated out of air it loses a part of its sulphur; heated in a current of air it forms sulphur dioxide and ferric oxide, and on this account is used in enormous quantities for the manufacture of sulphuric acid. *See also* FERROUS SULPHATE. *Ferrates:* When a mixture of finely divided iron and potassium nitrate is heated, it takes fire, and from the product when cold a solution of potassium ferrate is obtained on adding water. The formula of the salt is K_2FeO_4. Caustic potash precipitates it from the concentrated solution. It is black, and forms red solutions; only stable when very concentrated. *Iron carbonyl:* A brownish liquid of the probable formula $Fe(CO)_5$; very volatile; slowly formed when carbon monoxide is passed over gently heated, finely divided iron. *See also* POTASSIUM FERROCYANIDE *and* FERRICYANIDE, *and* PRUSSIAN BLUE. W. H. H.

Iron, Cutting. The word "iron" is applied to the cutting part of tools that have steel cutters, such as planes.

Irone (*Chem.*) *See* TERPENES.

Iron Founding. The process of making iron castings. It consists essentially of the processes of (1) MOULDING (*q.v.*); (2) Pouring in the molten iron which has usually been melted in a CUPOLA FURNACE (*see* FURNACES); (3) Breaking up the mould when the casting has cooled sufficiently; and (4) TRIMMING or FETTLING (*q.v.*) the casting, which is then ready to leave the foundry.

Iron Losses (*Elect. Eng.*) That part of the energy which is lost in a transformer (*q.v.*) or similar electromagnetic apparatus, through the Foucault or eddy currents (*q.v.*) and the HYSTERESIS (*q.v.*) The amount of the former loss is uncertain, but it may be reduced to a very small amount by laminating the core. *See* LAMINATION. The amount of energy lost by hysteresis depends upon the quality of the iron and the value of the magnetic induction in the iron. According to the well known formula of Steinmetz, if B be the induction, *h* a coefficient depending on the nature of the iron and the unit of mass chosen, then W, the work lost during each complete magnetic cycle, is given by the equation:

$$W = hB^{1.6}$$

Iron Ores (*Min.*) The principal ores of iron are the oxides HÆMATITE and MAGNETITE, the hydrates LIMONITE, TURGITE, GÖTHITE, and the carbonates CHALYBITE (or SIDERITE), and CLAY IRONSTONE (*q.v.*) *See also* IRON *and* IRON COMPOUNDS. There are many minerals besides (*e.g.* Iron Pyrites) which contain a large amount of iron, but owing to the presence of other elements (such as sulphur and phosphorus), which cannot be easily separated from the metal, they are not classed commercially as iron ores.

Iron Painting (*Dec.*) This work differs from ordinary house painting, because the surface is almost non-absorbent, while the principal object of the paint is to prevent rusting. The best paint for iron has long been the subject of discussion among engineers and painters. Red lead is generally favoured, but oxide of iron has also many adherents. Probably better than either are the several special iron paints manufactured for the purpose. When red lead is used it is mixed with boiled oil, and quickly dries very hard. The London County Council usually specifies white lead for repainting iron, but this is contrary to the opinion of those who have closely studied the subject. In repainting iron it is quite essential that all traces of grease, dirt, and rust be removed before the new paint is applied. A blow lamp or solvents are usually employed to remove the grease, while the rust is got rid of by thorough scraping and the use of wire brushes.

Iron Pattern (*Foundry*). A pattern (*q.v.*) is often made of iron in cases where a large number of castings have to be made from it. The iron pattern is itself a casting, and is made from an original wooden pattern, in which double contraction (*q.v.*) has to be allowed for.

Iron Pyrites (*Min.*) Sulphide of iron, FeS_2. Iron = 47, sulphur = 53 per cent. Cubic, in brassy yellow crystals or massive in radiating forms. It is hard and brittle. It was formerly used as a substitute for flint in firearms; now chiefly used in the manufacture of sulphuric acid, sulphate of iron, and alum. It nearly always contains a trace of gold, for which metal it is often mistaken, but from which it is at once distinguished by its hardness and brittleness. In some cases enough gold is present to pay as an ore of gold. Pyrites is of world wide distribution. Many dark clays and other coloured rocks owe their colour to finely disseminated Pyrites.

Iron Rope. Usually termed WIRE ROPE (*q.v.*)

Iron Stain on Linen. *See* CELLULOSE.

Ironstone. A general term for IRON ORE (*q.v.*)

Iron Tubing (*Eng., etc.*) *See* TUBING.

Ironwood. *See* WOODS.

Irradiation (*Phys.*) The name given to a peculiar optical effect in consequence of which very luminous bodies—for instance, an incandescent lamp filament—appear larger than the actual size. It is supposed to indicate that when a part of the retina is very strongly stimulated, the adjacent portions are also slightly affected, giving the sensation of light.

Irrationality of Dispersion (*Light*). Prisms of different materials under exactly similar conditions produce spectra of different lengths. If, however,

the spectra be made of equal lengths, and be made to correspond in one part, it will be found that they do not correspond in other parts, the separation of two given spectral lines depending upon the substance of the prism.

Irregular Pass (*Textiles*). *See* ENTERING.

Irregular Reflection (*Light*). Reflection which occurs at other than polished surfaces. Such surfaces are equivalent to myriads of small mirrors set at all angles, and their effect is to scatter the light in all directions. A typical instance is white unglazed paper. Even the smoothest surface is to some extent rough, and in consequence diffuses some light.

Irreversible Cycles (*Phys.*) When the pressure, volume, and temperature of a substance are altered in such a way that after a series of changes the substance returns to its original state, it is said to pass through a "cycle" of operations, and when the series of changes can only take place in one way the cycle is said to be "irreversible." For instance, if the substance during the cycle comes into contact with another body at a higher temperature than its own, then the operation is irreversible, for if it be attempted to perform the cycle the reverse way, at this particular point it is necessary that heat should pass from the cold substance to the hot body, which will not happen. Practical changes are almost inevitably irreversible. *Cf.* REVERSIBLE CYCLES.

Irrigation (*Civil Eng.*) The artificial supply of water for agricultural purposes. Usually effected by open channels on the surface of the land, and not by pipes or conduits.

—— (*Sewage*). The distribution of sewage over a large surface of ordinary agricultural ground, having in view a maximum growth of vegetation (consistent with due purification) for the amount of sewage supplied. The soil should be porous, as it is essential that the sewage should not only run over but through the soil before passing out as an effluent. On an average one acre of land is required for every hundred persons.

Isatin (*Chem.*), $C_6H_4<^{CO}_{NH}>CO$. Yellowish red prisms; melts at 201°; soluble in water and in alcohol. It dissolves in caustic soda solution with a violet colour; but on standing, the solution turns yellow, owing to the formation of the sodium salt of isatinic acid, $C_6H_4<^{CO.COONa}_{NH_2}$. Its chemical behaviour is that of a ketone (*q.v.*); but with phosphorus pentachloride it gives isatin chloride, $C_6H_4<^{CO}_{N}\geqslant C.Cl$. The latter compound is reduced to indigo by zinc dust. It was first obtained by oxidation of indigo with nitric acid. In some of its reactions (*e.g.* formation of salts with alkalis) isatin behaves according to the tautomeric form $C_6H_4<^{CO}_{N}\geqslant C.OH$, which is called PSEUDOISATIN.

Isatis Tinctoria (*Botany*). The WOAD PLANT belongs to the order *Cruciferae*, and yields a dye by fermentation of the leaves. The dye is now superseded by indigo.

Ischium (*Zoology*). The posterior bone of the hip girdle.

Isentropic Lines (*Heat*). Lines or curves of constant entropy. Frequently used as another name for ADIABATIC LINES, but the two are only synonymous in the case of reversible changes.

Isinglass. A refined form of gelatine obtained from fish membranes, especially the sturgeon. *See* ACCIPENSER *and* GELATINE.

Isinglass Gold Size (*Dec.*) Made from Russian isinglass. It is dissolved in water by means of heat, and afterwards added to spirits of wine, and then strained or filtered. It is used for gilding on glass.

Isis Headed Capital (*Architect.*) *See* HATHOR HEADED CAPITAL.

Iso- (*Chem.*) A prefix used in chemical nomenclature to indicate that the compound or group of compounds whose name or names begin with the prefix are isomeric (*see* ISOMERISM) with the compound or group of compounds having the same name, minus the prefix "iso." Examples:

$$\begin{array}{c} CH_3 \\ | \\ CH_2 \\ | \\ CH_2OH \end{array} \qquad\qquad \begin{array}{c} CH_3 \\ | \\ CHOH \\ | \\ CH_3 \end{array}$$

Propyl Alcohol. Isopropyl Alcohol.

Another example is afforded by methyl cyanide, CH_3CN, and methyl isocyanide, CH_3NC.

Isobar *or* **Isobaric Line** (*Meteorol.*) A line (or surface) in the air, at all points of which the barometric pressure has the same value.

Isobarometric Charts (*Meteorol.*) Charts on which lines are drawn through regions having simultaneously the same readings of the barometer.

Isobars (*Phys.*) Lines or curves showing the relation between the volume and temperature of a body when its pressure is constant. Also known as ISOPIESTIC LINES.

Isobilateral Leaf (*Botany*). The term applied to a type of leaf where the blade is vertical, *e.g.* IRIS.

Isocheimals (*Meteorol.*) Lines drawn on a map through regions which have equal winter temperatures.

Isochromatic Curve (*Phys.*) A term used to denote a line along which the colour is uniform in the case of the colour phenomena displayed by crystals in convergent polarised light.

Isochromatic Photography. Another name for ORTHOCHROMATIC PHOTOGRAPHY (*q.v.*) *See also* PHOTOGRAPHY.

Isochronism (*Watches and Clocks*). The performance of *unequal* arcs of vibration in *equal* intervals of time.

Isochronous (*Phys.*) Having equal times. Applied to uniform motion, or more correctly to two or more different motions which occur in the same time, *e.g.* two pendulums which swing exactly in time with each other.

Isoclinic Lines (*Phys.*, *Meteorol.*) Lines connecting those parts of the Earth's surface at which the magnetic inclination or dip is the same.

Isocyanides (*Chem.*) *Also called* CARBYLAMINES, CARBAMINES, *or* ISONITRILES. Compounds of the formula $R-NC$, where R stands for an alcohol radical. They are isomeric with the organic cyanides or nitriles which have the formula $R-CN$. They are distinguished from the latter by having a disagreeable smell, lower boiling points, and by their reactions. They are obtained by heating an alkyl

iodide with silver cyanide; also by heating a primary amine with chloroform and alcoholic potash:

$$C_2H_5I + AgCN = C_2H_5NC + AgI.$$
$$C_6H_5NH_2 + CHCl_3 + 3KOH = \underset{\text{Phenyl Isocyanide.}}{C_6H_5NC} + 3KCl + 3H_2O.$$

The isocyanides are liquids, sparingly soluble in water, readily soluble in alcohol and ether; they all have the same disagreeable smell, which produces nausea and headache. When heated they undergo rearrangement into cyanides; with acids they undergo hydrolysis to amines and formic acid:

$$C_2H_5NC + 2H_2O = C_2H_5NH_2 + HCOOH.$$

Their formation from and decomposition into primary amines proves that the nitrogen is attached to carbon. Methyl isocyanide boils at 59°, ethyl isocyanide at 79°, and phenyl isocyanide at 166°, at the same time polymerising. Their formation is used as a test for primary amines and chloroform.

Isocyclic Ring (*Chem.*) *See* CLOSED CHAIN COMPOUNDS.

Isodynamic Lines (*Phys.*, *Meteorol.*) Lines connecting those parts of the Earth's surface at which the total magnetic intensity (in the line of dip) is the same.

Isogeothermic Lines (*Phys.*, *Meteorol.*) Lines connecting those places on the Earth's surface at which the mean temperature of the soil is the same.

Isogonic Lines (*Phys.*, *Meteorol.*) Lines connecting those parts of the Earth's surface at which the magnetic declination is the same.

Isohels (*Meteorol.*) Lines connecting places having the same amount of sunshine.

Isohydric Solutions (*Chem.*) Solutions of substances (salts, acids, bases) having a common ion, of such strength that the concentration (gram molecules per litre) of the ion in each solution is the same. Such solutions undergo no change when they are mixed.

Isohyets (*Meteorol.*) Lines connecting places having the same amount of rainfall.

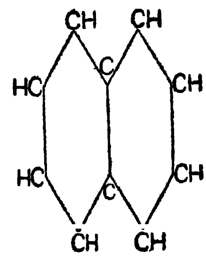
Isomerism. Compounds composed of the same elements and having the same molecular weight are said to be isomeric. There are various kinds of isomerism. When the same atom or group of atoms is substituted at different places in the molecule of a parent compound, we have POSITION ISOMERISM; *e.g.* propane yields normal and isopropyl alcohols and iodides:

CH_3	CH_3	CH_3	CH_3	CH_3
$\vert$	$\vert$	$\vert$	$\vert$	$\vert$
CH_2	CH_2	$CHOH$	CH_2	CHI
$\vert$	$\vert$	$\vert$	$\vert$	$\vert$
CH_3	CH_2OH	CH_3	CH_2I	CH_3
	Normal Propyl Alcohol.	Isopropyl Alcohol.	Normal Propyl Iodide.	Isopropyl Iodide.
	Isomeric.		Isomeric.	

When different radicals are united together by means of a di- or polyvalent element to form compounds which fulfil the requirements of the above definition of isomeric compounds, we have what is called METAMERISM; *e.g.* the following ethers are metameric, also the amines:

$$\underset{\text{Methylpropyl Ether.}}{\begin{matrix}CH_3\\C_3H_7\end{matrix}\!\!>O} \quad \underset{\text{Diethyl Ether.}}{\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\!\!>O} \quad \underset{\text{Trimethylamine.}}{\begin{matrix}CH_3\\CH_3\\CH_3\end{matrix}\!\!>N} \quad \underset{\text{Methylethylamine.}}{\begin{matrix}C_2H_5\\CH_3\\H\end{matrix}\!\!>N} \quad \underset{\text{Normal and Isopropylamines.}}{\begin{matrix}C_3H_7\\H\\H\end{matrix}\!\!>N}$$

When the same atoms or groups of atoms are similarly united chemically, but have a different spacial arrangement, we have what is called Stereoisomerism or Geometrical Isomerism. This form of isomerism is dealt with separately. *See* STEREOISOMERISM. The number of isomerides derivable from one parent compound increases very rapidly with the increase of complexity of the compound. While butane has only two isomeric forms, $CH_3CH_2CH_2CH_3$ and $(CH_3)_2.CH.CH_3$, tridecane, $C_{13}H_{28}$, has 802 isomerides. Naphthalene—



has ten isomerides when two hydrogen atoms are replaced by two different atoms or groups, but over 10,000,000 isomerides when eight hydrogens are replaced by eight different groups. It must not be inferred that if two compounds are isomeric they are easily converted into each other, or are even nearly related. This may be so or not. Hydrazobenzene is easily converted into benzidine, $C_6H_5NH.NH.C_6H_5 \rightarrow H_2N.C_6H_4.C_6H_4NH_2$; but these isomerides are widely different chemically. Propyl alcohol is not readily changed to isopropyl alcohol, but both these substances have certain properties in common. The most numerous examples of isomerism are to be found in organic chemistry; but in recent years numerous examples have been discovered in inorganic chemistry. Examples are: the sodium potassium sulphites, $SO_2\!<\!\begin{matrix}OK\\Na\end{matrix}$ and $SO_2\!<\!\begin{matrix}ONa\\K\end{matrix}$; the sodium potassium thiosulphates, $SO_2\!<\!\begin{matrix}OK\\SNa\end{matrix}$ and $SO_2\!<\!\begin{matrix}ONa\\SK\end{matrix}$; the chromium bromides,

$$\underset{\substack{\text{Blue.}\\\text{All Br precipitated}\\\text{by }AgNO_3.}}{[Cr(H_2O)_6]Br_3} \text{ and } \underset{\substack{\text{Green.}\\\frac{1}{3}\text{ Br precipitated}\\\text{by }AgNO_3.}}{\left[Cr\begin{matrix}Br_2\\(H_2O)_4\end{matrix}\right]Br2H_2O.}$$

See also, in connection with this subject, TAUTOMERISM *and* WERNER'S THEORY.

Isometric Lines (*Phys.*) Lines or curves showing the relation between the pressure and temperature of a body when its volume is constant. Also known as ISOPLERES.

Isomorphism (*Chem.*) Literally means having the same form. In chemistry it is used to indicate the identity of crystalline form shown by compounds containing similar elements similarly combined together. The following are examples of isomorphous compounds:—The alums: they have the general formula $R_2SO_4M_2(SO_4)_3 24H_2O$; the double sulphates of the general formula $R_2SO_4MSO_4 6H_2O$, when R = K, NH_4, or Na, and M = Mg, Mn, Fe, Co, or Ni; the arseniates and phosphates, as sodium arseniate, $Na_2HAsO_4 12H_2O$, and sodium phosphate, $Na_2HPO_4 12H_2O$; the sulphates and chromates, as K_2SO_4 and K_2CrO_4. The term is also applied to the elements occurring in isomorphous groups; for

instance, aluminium, chromium, iron, and manganese are sometimes called isomorphous elements because the alums form an isomorphous group. Identity of crystalline form is not by itself a proof of isomorphism: thus potassium nitrate crystallises in the same form as arragonite—a form of calcium carbonate; but these substances are not isomorphous, for calcium and carbon are not similar elements to potassium and nitrogen. A good test of isomorphism besides similarity of form is the formation of mixed crystals. Thus a crystal of common alum will grow in a solution of chrome alum by having the latter deposited on it in such a way that the shape of the crystal does not alter; or a mixed solution of these two alums will deposit crystals containing both alums, while their shape is that of alum or chrome alum. The identity of crystalline form in isomorphous substances is not perfect, the angles between corresponding faces in two isomorphous substances being usually slightly different. The principle of isomorphism has occasionally been of use in atomic weight determinations. Thus aluminium is isomorphous with iron in a number of compounds, so that if ferric oxide has the formula Fe_2O_3, the isomorphous aluminium oxide will most probably have the formula Al_2O_3; so that if the percentage composition of this oxide is known, the atomic weight of aluminium is known. One element may belong to more than one isomorphous group. Manganese is isomorphous with iron in its sulphate and in its alums; it is isomorphous with sulphur in the manganates and sulphates, *e.g.* K_2MnO_4 and K_2SO_4; it is isomorphous with chlorine in the permanganates and perchlorates, *e.g.* $KMnO_4$ and $KClO_4$.—W. H. H.

Isomorphism (*Min.*) The identity in form of some minerals of the same groups. Isomorphous minerals can and do replace one another to a considerable extent; *e.g.* the sulphide of lead, GALENA, is often partially replaced by the isomorphous sulphide of silver, ARGENTITE, without any apparent alteration in the crystal of Galena.

Isonephs (*Meteorol.*) Lines connecting places having the same amount of cloudiness.

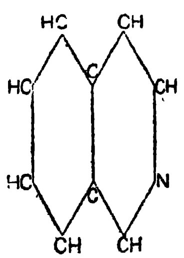
Isonitriles (*Chem.*) *See* ISOCYANIDES.

Isonitroso Compounds (*Chem.*) *See* NITROSO COMPOUNDS.

Isopiestic Lines (*Phys., Meteorol.*) *See* ISOBARS.

Isopleres (*Phys.*) *See* ISOMETRIC LINES.

Isoquinoline (*Chem.*)



A colourless crystalline solid; melts at 23°; boils at 240°. Its properties and behaviour are similar to those of quinoline (*q.v.*) It occurs in coal tar, and is obtained from this source. On oxidation it yields phthalic acid and cinchomeronic acid. It is used in the preparation of the dye quinoline red, and is of importance as being the parent substance of a number of alkaloids, *e.g.* Papaverine and Narcotine.

Isotherals (*Meteorol.*) Lines drawn on a map through regions which have equal summer temperature.

Isothermal Change (*Phys.*) A change in the pressure and volume of a substance, especially of a gas, which occurs without change of temperature.

Isothermal Charts (*Meteorol.*) Charts on which lines are drawn through regions having simultaneously the same readings of the thermometer.

Isothermal Line *or* **Curve** (*Phys.*) A curve showing the relation between the changes of pressure and volume of a substance which is kept at constant temperature. For a perfect gas the curve is a hyperbola, and is represented by the equation PV = a constant.

Isotherms (*Meteorol.*) Lines connecting places having an equal temperature.

Isothiocyanates (*Chem.*) *See* MUSTARD OILS.

Isotonic Solutions (*Chem.*) Solutions having the same osmotic pressure (*q.v.*)

Isotropic Body (*Phys.*) A body homogeneous in all directions as regards its physical properties.

Istesso tempo, l' (*Music*). The same time; put after an alteration of time to show that the former tempo is to be resumed, or as warning that there is to be no change in the time.

Italian (*Textile Manufac.*) A lining fabric, usually with a five end weft sateen weave. Highly polished in the finishing and pressing.

Italian Pink (*Dec.*) A pigment similar to Dutch pink (*q.v.*)

Italian Schools of Painting. *See* PAINTING, SCHOOLS OF

Italic, Italics (*Typog.*) The name applied to a printing type invented about 1500 by Aldus Manutius, a Venetian printer. Italic type or italics are employed in modern books, etc., to attract the attention of the reader, for emphasis, or to distinguish a word or phrase from others in the same context. The words in parentheses which follow the terms in this work are set in italics.

Ivory (*Zool.*) The toothlike substance of the tusks of elephants and also of the teeth and tusks of the narwhal, boar, and hippopotamus.

——, Artificial. A form of CELLULOID (*q.v.*) often used as an imitation of and substitute for ivory.

Ivory Black (*Dec.*) This is made by calcining waste cuttings of ivory. It is of an intense black colour, tending toward a bluish hue; is not a good drier, but makes a good glaze. *See* GLAZING. Much so-called ivory is real boneblack

Ivory, Vegetable (*Botany*). The ripe seeds of the ivory nut palm or Corozo nut, ***Phytelephas macrocarpa*** (order, *Palmæ*), a native of Central America. The hard albumen is much used for making small articles, which are turned in the lathe.

J (*Phys.*) The symbol for JOULE'S EQUIVALENT (*q.v.*)

Jaborandi. A powerful sudorific drug derived from the dried leaflets of a Brazilian shrub, ***Pilocarpus pennatifolius*** (order, ***Rutaceæ***). The alkaloid Pilocarpine and its salts are used in ophthalmic practice.

Jack. A term applied to a great variety of mechanical contrivances, often to machines which have taken the place of human labour, *e.g.* the automatic machine for turning a spit in roasting meat. Applied to a form of roller, winch, a wedge used in mining, an oscillating lever, to a spring clip forming the terminal in a telegraph or telephone wire by means of which instruments can be rapidly brought into circuit, etc., etc.

—— (*Archæol.*) A vessel made of waxed leather, used either for holding liquor (*see* BLACK JACK) or for drinking from, *e.g.* a mug or tankard.

—— (*Arm.*) A sleeveless tunic or coat of fence, usually made of leather, worn by footmen and archers from the fourteenth to the sixteenth century. Later forms of the Jack were plated with iron. The Jack was succeeded by the BUFF COAT (*q.v.*)

—— (*Eng.*) A piece of mechanism, usually portable, used for lifting heavy weights through a short distance; *e.g.* lifting a heavy vehicle so that its wheels are off the ground. It is usually worked by hand, the force being applied by levers, or by a screw in a SCREW JACK or BOTTLE JACK, or by a small hydraulic press in the case of a HYDRAULIC JACK.

—— (*Lace Manufac.*) A term used in the lace trade. It has various meanings; *e.g.* a frame of wood or iron with projecting wires to hold bobbins filled with material. This description applies to the jack used by the warper, and is analogous to the term "creel" used in the weaving trade. *See also* JACKS.

Jacket (*Eng., etc.*) A general term for a casing used to keep some object at a constant temperature; *e.g.* a STEAM JACKET (*q.v.*) or a WATER JACKET (*q.v.*)

—— (*Paper Manufac.*) A special felt cover for the couch roll, which serves to remove excess water from wet paper during manufacture.

Jack Frame (*Cotton Spinning*). A fine gauge on the roving frame with one row of flyer spindles only. Used for producing fine rovings for very fine spun yarns.

Jacking Delivery Motion (*Cotton Spinning*). Used on fine spinning mules for delivering a short length of roving through draw rollers after "jacking" has taken place, to compensate for the contraction during twisting.

Jacking Motion (*Cotton Spinning*). Used on fine spinning mules for stopping delivery of roving through rollers, just before the carriage reaches the end of its traverse outwards. By this means an extra draft is given to the spun thread.

Jacking Off (*Spinning*). The motion in mule spinning for reversing the twist or taking out the excessive twine in the yarn, near the top of the spindle, before winding on to the latter.

Jacking Up (*Eng.*) Lifting a heavy object by means of a JACK (*q.v.*)

Jack in the Box (*Cotton Spinning*). *See* DIFFERENTIAL MOTION.

Jack Off (*Lace Manufac.*) To wind short lengths of thread off a number of bobbins, and make them into one continuous length.

Jack Plane (*Carp.*) The plane used for roughing out wood and producing an approximately true surface. Its length is usually from 15 to 18 in., and the width of the cutting iron 2 to $2\frac{1}{2}$ in. English jack planes are usually made of beech. Iron planes are much used in America, and are being gradually introduced in England.

Jack Rafters (*Carp.*) The short rafters fixed to the hip rafters. *See* ROOFS.

Jacks (*Lace Manufac.*) The SELECTORS or INTERCEPTORS used in the lace curtain machine.

—— (*Textile Manufac.*) A type of lever in dobby looms in connection with the lowering and lifting of the heald shafts.

Jacobean Architecture. *See* RENAISSANCE ARCHITECTURE.

Jacquard (*Cotton Weaving*). A pattern machine used for the production of floral and other ornamental designs in cloth weaving where the adoption of tappet or dobby would be useless. These machines are specially constructed for different kinds of work, the chief makes being SINGLE CYLINDER, TWO CYLINDER, CROSS BORDER, and TWILLING JACQUARD.

—— (*Lace Manufac.*) Mechanism connected to the lace machine for the purpose of producing the fabric. (Jacquards vary considerably in their application to the various machines used in the textile trades.) The form best adapted for lace curtain machines is a special form of MANCHESTER TOP, and for the "Levers" machine a modification known as the "SPRING DROPPER" JACQUARD, wherein the various movements of the guide bars are accomplished by the aid of droppers (*q.v.*) or wedges. Great accuracy of movement is attained by the latter method. *See also* SILK WEAVING.

Jade (*Min.*) A compact tough silicate of magnesium and calcium of variable composition. It is much used by the Maoris for weapons and by the Chinese in the manufacture of cups, images, rings, etc. Also called Nephrite and Axe Stone. Distinguished from Jadeite, which is a sodium aluminium silicate. Jade comes chiefly from China, New Zealand, Corsica, and North America.

Jag Bolt (*Eng.*) A bolt roughened on the part of its axis or shaft above the screw, in order that it may be held fast by the material (wood, lead, etc.) in which it is embedded.

Jalap (*Botany*). The dried tuberculated roots of *Ipomæa purga* (order, *Convolvulaceæ*), imported from Mexico, are the source of the purgative resin JALAP.

Jamb (*Build.*) (1) The brickwork on each side of a fireplace. (2) The sides of a door or window opening.

Jambe *or* **Gamb** (*Her.*) The paw and part of a leg of any animal. If extending only to the first joint it is called a PAW.

Jamb, Jambart, Jambeau (*Arm.*) A defence for the leg, generally made of cuir-bouilli until the fifteenth century, subsequently of iron. *See* BAINBERGS, ARMOUR, *and* GREAVES.

Jamb Lining (*Carp. and Join.*) The wood finishings that cover the sides of window and door openings.

Jamesonite (*Min.*) A sulph-antimonide of lead, $2PbS, Sb_2S_3$. It is orthorhombic and usually occurs in very fine capillary crystals. From Cornwall, Siberia, Hungary, etc.

Japanese Paper. Made from the bark of *Morus papifera sativa*, used for expensive printing, and especially for printing proofs of engravings and etchings.

Japanners' Gold Size (*Dec.*) Size is simply a weak glue water made with gelatine of various degrees of purity, ranging from isinglass or some form of inferior gelatine which has been freed from colouring matter down to the cheapest and darkest glue. Gold size is so called from its use by gilders, and is made from very pure gelatine. Japanners use an exactly similar size.

Japanning (*Dec.*) This is a species of enamelling (*q.v.*), and, like it, is distinguished from ordinary varnishing by the japan being dried in hot stoves. Japanning, therefore, is restricted to articles of no great size, usually of metal. Japanning is done with a suitable varnish, and may be in any colour, but black is by far the commonest. Several coats of the varnish are applied for good work, and each coat is dried in the stove before the next is applied. The heat is of course much less than in enamelling, but is often as much as 150° C. The varnishes used are copals with less oil in them, but more turpentine than in an ordinary copal varnish. Japanning gives a more brilliant and a more durable surface than any ordinary varnishing can do, but costs considerably more. Tin boxes and canisters, articles of ironmongery, *papier maché* goods, slate for marble imitation, and leather are often japanned. Japan is always *coloured with mineral pigments*, on account of the heat it has to stand. The black japan owes its colour to the asphaltum from which it is made.

Japetus (*Astron.*) The most distant satellite of Saturn; distant 2,261,000 miles. Period 79d. 7h. 54m. Discovered by Cassini in 1671.

Jardinière. A vase or stand for the display of growing flowers, either inside or outside a house; also for the display of cut flowers as a table decoration.

Jargoon (*Min.*) A variety of ZIRCON (*q.v.*) of a smoky colour. Used as a gem.

Jar, Leyden (*Elect.*) *See* LEYDEN JAR.

Jarrah. *See* WOODS.

Jasmine *or* **Jasminum** (*Botany*). A genus of fragrant flowered plants belonging to the *Oleaceæ* (Olive order). The flowers of *J. officinale* and *J. grandiflorum* yield on distillation a volatile oil used in perfumery.

Jasper (*Min.*) An opaque coloured variety of silica in the massive state. It is really an intimate mixture of the crystalline anhydrous silica Quartzine and the amorphous hydrated silica Opal, together with other impurities. Of all colours, chiefly red, yellow, and green. Often found in veins in volcanic rocks, or as pebbles from the erosion of these veins. Of very wide distribution.

Jatropha (*Botany*). A genus of the *Euphorbiaceæ* found in tropical countries. The seeds of several species yield by pressure oils used medicinally, for burning, and to adulterate croton oil.

Javelin (*Arms*). A light spear used as a missile by both horse and foot in the Middle Ages. It is still carried in this country for display, *e.g.* by the footmen attending a judge on State occasions.

Jaw (*Eng., etc.*) The part of a vice, clamp, chuck, etc., which actually comes in contact with the piece of work to be held.

Jazerant (*Arm.*) Light armour composed of overlapping pieces of steel fastened by one edge to some fabric. Used in the fourteenth and fifteenth centuries in place of heavy chain or plate armour.

Jemmy. A short crowbar.

Jerkin (*Cost.*) A short jacket something like a doublet, worn by men in the sixteenth and seventeenth centuries.

Jesses (*Her.*) *See* HAWK BELLS AND JESSES.

Jet. (1) A fine stream of fluid; (2) the nozzle or pipe from which such a stream issues, *e.g.* the nozzle from which gas issues for burning.

—— (*Min.*) A hydrocarbon compound allied to Cannel Coal in composition. It is light, and takes a good polish, and hence is used for ornamental purposes. Chiefly from Whitby.

Jet Condenser (*Eng.*) The device used for condensing the steam in the older type of steam engines. The exhaust steam escapes into a space in which it mingles with cold water issuing from a jet or nozzle. The condensed steam and the water are removed by a pump, often termed an Air Pump. *See* AIR PUMP (*Eng.*)

Jets (*Astron.*) Meteoric vapours ejected from the coma of a comet towards the sun, and immediately driven back by the solar repulsion.

Jetty (*Architect.*) A portion of a building extending beyond the face of the part below, as in the case of a projecting upper storey in a half-timber building.

—— (*Civil Eng.*) A small pier or landing stage.

Jeux d'Anches (*Music*). The French term for reed stops on an organ.

Jewels. *See* PRECIOUS STONES.

Jeyes' Disinfectant. *See* CREOSOTE.

Jib (*Eng.*) The projecting part of a crane from the end of which the chain hangs down. *See also* CRANES.

—— (*Eng., etc.*) An alternative spelling of GIB (*q.v.*)

Jib Cranes (*Eng.*) *See* CRANES.

Jib Door (*Joinery*). A secret door which, when shut, resembles the wall in which it is fixed.

Jig (*Cycle Manufac.*) A device for holding parts of cycles (*e.g.* frames) in their proper relative positions while they are being operated on by hand or otherwise.

—— *or* **Jigger** (*Mining*). An appliance for sorting or dressing ore worked either by hand or by machinery.

—— *or* **Jigger Saw** (*Carp., etc.*) A narrow saw having a reciprocating motion, actuated by mechanism. Most of the work for which this saw was used is now carried out by the band saw (*q.v.*)

Jigger. A term for many mechanical contrivances used in various trades; *e.g.* in pottery manufacture, a vertical lathe upon which are made plates, saucers, dishes, and other flat and pressed wares. *See also* JIG.

Jil Barrow (*Eng.*) A flat wheelbarrow without sides, used in foundries and engineering shops.

Job (*Print.*) Work which occupies less than a sheet.

—— (*Trades*). (1) Any kind of odd work. (2) A small contract.

Jobbing Founts (*Typog.*) Types suitable for jobbing work (*q.v.*); generally of a fancy character.

Jobbing Machines (*Print.*) Small platen machines, worked either by a pedal or by power; used for jobbing work.

Jobbing Work (*Typog.*) This includes all kinds of small work, such as cards, programmes, memorandums, circulars, bills, etc.

Job's Tears (*Botany*). A grass, *Coix lachryma* (order, *Gramineæ*), belonging to China and India, grown as a cereal in Northern India. The hard "seeds" are used for ornaments, being made into necklaces, etc.

Joggle (*Carp.*) A simple joint formed by notching two pieces of timber at a point where they cross each other; *e.g.* rafters may be joggled to the purlins on which they lie.

—— (*Eng.*) A small projection on a piece of metal work, which fits into a corresponding socket on another part for the purpose of checking lateral motion.

Joggled Joint (*Masonry*). A projection formed on one stone to fit into another.

Joiner's Cramp. A long piece of T or bar iron, with a movable shoe at one end and a screw press at the other. Used for squeezing up the shoulders of tenons in doors, etc.

Joinery. The branch of wood working which deals with the more finished and ornamental parts of a building, such as doors, windows, staircases, internal fittings and fixtures; also certain classes of furniture and many articles constructed in a well finished style. *Cf.* CABINETMAKING *and* CARPENTRY.

Joint (*Bind.*) The part of the cover where it joins the back of the book on the inside, and where a kind of hinge is formed. In whole-bound books the joints are generally formed of the same material (pared down) as the cover; in half-bound books the joints are sometimes covered with cloth if the book is likely to be much used. In other cases the joints are simply covered over with the end papers, which are pasted well down into the joints.

—— (*Elect. Eng.*) The main essentials of a good electrical joint are three: (1) Electrical conductivity. (2) Mechanical strength and durability. (3) Facility for insulation. A joint may be soldered, brazed, or welded, or may be "dry," *i.e.* the two parts of the conductor are brought into close metallic contact and kept in position by twisting, lapping with wire, by a clamp, etc.

Jointing (*Carp. and Joinery*). (1) The making of various joints. *See* TENON, DOVETAIL, *etc.* (2) The truing up of large members of a structure in which considerable accuracy is required.

—— (*Eng.*) Applied to a great variety of operations, such as the connecting together of lengths of piping. In foundry work jointing means the formation of suitable surfaces on two parts of a mould which have to be separated when the pattern is withdrawn; such surfaces are usually faced with fine sand.

—— *or* **Jointer Plane** (*Joinery*). The largest form of plane, resembling a jack or trying plane in form, but 28 or 30 in. long. Used in truing up large pieces of timber.

Joints (*Carp. and Joinery*). *See* DOVETAIL, HALVING, LAP JOINT, MORTICE AND TENON, *etc.*

—— (*Geol.*) Divisional planes of secondary origin, formed in various rocks at or near the time of their consolidation. Joints usually occur in two or more transverse sets, which cut across the bedding planes of the rocks in such a manner as to divide them up into masses with some approach to geometrical regularity. They are spaced at about equal distances apart, and the rock affected does not usually tend to split between them in directions parallel to the joints. This feature distinguishes joints from cleavage. Except in the case of strata of very uniform lithological character, joints tend to a "bonded" arrangement, like that of masonry or brickwork. The joints formed in rocks which have cooled from a state of fusion generally traverse them in such a manner as to divide the eruptive rock into polygonal prisms, whose axes are perpendicular to the surface of cooling.

Joists (*Eng., Build., etc.*) A general term for beams and girders, especially the horizontal beams which carry the floors in a building. *See also* FLOORS *and* ROOFS.

Jolley (*Pot.*) A machine used in the manufacture by machinery of cups, jugs, and hollow ware generally.

Joule (*Phys.*) A unit of work equal to ten million (10^7) ergs. It is occasionally used in electrical calculations; but the unit of POWER, which is one joule per second, is more frequently required. This unit of power is termed the WATT (*q.v.*)

Joule's Equivalent, J. (*Heat*). The amount of mechanical work which can be obtained from one unit of heat if entirely converted into work; also termed the MECHANICAL EQUIVALENT OF HEAT. The value of this equivalent has been the subject of many experiments since those of Joule; it is found that one calorie is equivalent to $4{\cdot}189 \times 10^7$ ergs, or that the heat required to raise 1 lb. of water through 1° Fahrenheit is equivalent to 778 foot pounds.

Joule's Law (*Elect.*) The heat produced by a current in a conductor is proportional to the time during which it flows, the resistance of the conductor, and to the square of the strength of the current. If C be the strength of the current in ampères, t the time in seconds, R the resistance of the conductor in ohms, and H the amount of heat produced in calories, then $H = C^2Rt \times {\cdot}24$.

Journal (*Eng.*) The part of a shaft which is actually in contact with the bearings. It must be truly cylindrical, and it is often of smaller diameter than the rest of the shaft.

Journeyman. A qualified mechanic or workman.

—— (*Clocks*). *See* INDICATOR DIALS.

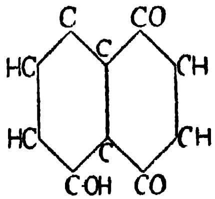
Joy's Valve Gear (*Eng.*) A set of levers forming what is termed Radial Gear, sometimes used instead of eccentrics to actuate the slide valves of a locomotive. The levers are driven by a link attached to the connecting rod.

Jubé (*Architect.*) The rood loft over the screen which separates the chancel from the nave. So named from the fact that the priest pronounced the words *jube domine benedicere* from the rood loft previous to reading the lessons. *See* ROOD SCREEN.

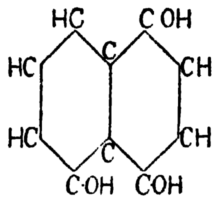
Judge (*Mining*). A measuring rod or staff used in mines.

Juglandaceæ (*Botany*). An order of Dicotyledons belonging to north temperate and tropical Asia. The Walnut (*Juglans regia*) is the best known genus, and is valued not only for its fruit, but also for its wood and an oil expressed from the seeds.

Juglone (*Chem.*)



(5-oxy-α-naphthoquinone). Garnet red needles (from alcohol); melts with decomposition at 150°. Soluble in chloroform, less soluble in alcohol. The powder causes sneezing. It is obtained from walnut shells. On reduction it gives α-hydrojuglone,



which forms colourless plates, melts at 169°, is sparingly soluble in water, readily in alcohol and ether; its solution is oxidised on standing in air to juglone. α-Hydrojuglone is poisonous. On distillation it is changed to the isomeric β-hydrojuglone. The hydrojuglones occur in unripe walnut shells.

Julian Calendar (*Astron.*) The calendar as revised by Julius Cæsar, B.C. 45. It is still, with trifling modification, used by all civilised nations

Julian Period (*Astron.*) The Julian period consists of 7,980 Julian years, each containing exactly 365¼ days. Its starting point or epoch is January 1, 4713 B.C.

Jumper (*Mining*). A form of hand drill shaped like a straight crowbar. It has a chisel-like cutting edge, and cuts a hole by a simple rising and falling motion. The blow may be intensified by striking the head of the tool with a hammer.

—— *or* **Through Stone** (*Build.*) *See* THROUGH STONE.

Jumping Up (*Forge*). Thickening the end of an iron rod by hammering it in the direction of its length; also termed UPSETTING.

Jump Joint (*Eng.*) A BUTT JOINT (*q.v.*)

Juncaceæ (*Botany*). A Monocotyledon order found in moist places in temperate and cold climates. The RUSHES (*Juncus*) are used for making baskets and similar articles, and some species are used as fodder.

Junctions (*Civil Eng.*) A point where a branch enters or leaves another line. The main rail is furnished with gaps, and the branch rail has SWITCHES or POINTS (*q.v.*) and CROSSINGS or GUARD RAILS.

Juniper (*Botany*). An oil is distilled from the unripe fruits of *Juniperus communis* (order, *Coniferæ*) and used in medicine. The fruits are also used in making gin. *See also* WOODS.

Junk Ring (*Eng.*) A cast iron ring fixed to a piston in order to squeeze the packing (*q.v.*) into close contact with the sides of the cylinder.

Juno (*Astron.*) One of the larger minor planets or asteroids discovered by Harding in 1804.

Jupiter, Planet (*Astron.*) Distance from Sun, 483,000,000 miles; diameter, 86,500 miles; periodic time, 11·86 years. Five satellites, whose periods are respectively 1d. 18½h., 3d. 13¼h., 7d. 4h., and 16d. 18h; the period of the innermost satellite is not yet accurately known.

Jupon (*Cost.*) A close fitting tunic, originally worn by knights under the hauberk or cuirass: later a sleeveless surcoat reaching to the hips, often of rich material blazoned with arms, and worn over armour. That of the Black Prince is still to be seen in Westminster Abbey. *See* COAT ARMOUR.

Jurassic System (*Geol.*) The group of rocks which embraces all the strata between the top of the Rhætic Beds (*q.v.*) and the base of the Neocomian Rocks. It therefore includes the Lias and the Oolites. These rocks are typically developed in the Swiss Jura, whence the name.

Justification (*Typog.*) The adjustment or even spacing of words and lines in a given measure.

Jute (*Botany*). The plant *Corchorus capsularis* (order, *Tiliaceæ*): also *C. olitorius* is the source of JUTE or GUNNY, which is obtained by maceration of the bast fibres, as in flax and hemp. Used in the manufacture of sacks, paper, carpets, cordage, etc.

K (*Elect.*) A symbol used for the SPECIFIC INDUCTIVE CAPACITY of a dielectric (*q.v.*)

—— (*Phys., etc.*) A symbol often used for the MOMENT OF INERTIA (*q.v.*) The letter I is also used.

k (*Elect.*) A symbol used for the MAGNETIC SUSCEPTIBILITY (*q.v.*) of iron and steel. Its value is easily obtained from the tables of PERMEABILITY (*q.v.*) by the formula

$$\mu = 1 + 4\pi k$$

in which μ equals the Permeability. It is evident that if μ be large, k is very approximately equal to μ divided by 4π or 12·5.

—— (*Phys., etc.*) A symbol frequently used to denote a constant.

Kaaba. *See* CAABA.

Kachin (*Photo.*) The name of a substance used as a developer. It is a white crystalline powder readily soluble in water. The use of bromide with this developer is unnecessary, and in fact greatly retards its action. With plates that have been considerably over-exposed it will yield good negatives.

Kahnisin (*Meteorol.*) The hot winds of Egypt.

Kakemono (*Art*). The name given by the Japanese to a wall picture, generally painted on silk or paper, and mounted on rollers. It is the custom in Japanese houses to roll up the kakemonos periodically and substitute others in their places.

Kale (*Botany*). A cultivated form of *Brassica oleracea* (order, *Cruciferæ*), used as a vegetable.

Kaleidoscope. An optical toy, consisting of a tubular body containing two (or three) mirrors arranged at angles of 60°. Small objects (*e.g.* pieces of coloured glass, beads, etc.) are contained in a glass compartment at one end; on looking through the other end, the objects and their reflection in the mirrors form symmetrical patterns, which change as the instrument is rotated. It is employed to a small extent by designers.

Kalinite (*Min.*) *See* ALUM.

Kampylite (*Min.*) A variety of MIMETITE (*q.v.*) occurring in barrel shaped crystals, whence the name. Found at Dry Gill Mine in Cumberland.

Kann (*Mining*). A Cornish name for FLUORSPAR (*q.v.*)

Kaolin (*Geol.*) Another name for CHINA CLAY. It originates chiefly through the prolonged action of subterranean waters upon felspar—chiefly upon the potash felspars Orthoclase and Microcline. As a rule kaolin occurs only in those granite areas whose surfaces have not been lately beneath the sea and which have not been recently pared to any great depth by glacial action. Kaolin is almost absent from the north of England and from the whole of Scotland. Most clays were originally impure forms of kaolin. It is a hydrous silicate of aluminium, $2H_2O . Al_2O_3 . 2SiO_2$. Approximate composition, silica = 46·3, alumina = 39·8, water = 13·9 per cent. Monosymmetric. The crystals are microscopic plates; it appears to the naked eye as a fine white clay, with a slightly soapy feel. From Cornwall, Saxony, Austria, China, and the United States. It is used with *Petuntse*, a similar material, to form hard paste porcelain. *See* POTTERY AND PORCELAIN *and* CHINA CLAY.

Karri. *See* WOODS.

Karrusel (*Watches*). A modern form of tourbillon invented by B. Bonniksen, in which the rotary escapement carriage turns at a much slower rate than in Breguet's original invention, making the watch stronger and cheaper, while gaining the same object *See* TOURBILLON.

Kaspine Leather. A new kind of white leather tanned by means of formaldehyde and an alkali. The process was discovered by E. E. M. Payne in 1898.

Kater's Pendulum. *See* PENDULUMS.

Kathode *or* **Cathode** (*Elect.*) The conductor or electrode (*q.v.*) by which an electric current leaves a conducting system, *e.g.* a liquid or gas.

Kathode Rays (*Elect.*) An emanation from the kathode in a highly exhausted vacuum tube. These rays probably consist of a stream of negatively electrified particles, shot out from the kathode: they travel through the stream in straight lines, and can be deflected or even brought to a focus by a plate of suitable shape placed in their path; they are also deflected by a magnet. They are either identical with or give rise to the emanation known as LENARD RAYS (*q.v.*) *See also* RADIATION.

Kation *or* **Cation** (*Elect.*) The ION (*q.v.*) in a solution, which travels towards the KATHODE (*q.v.*)

Kauri. *See* WOODS.

—— (*Dec.*) Kauri or Cowrie copal is a resin exuded by two trees, *Dammara australis* in New Zealand, and *D. ovata* in New Caledonia. It is used for varnish making. In commerce the only kauri used is the sub-fossil exudation, which is dug up in lumps, often weighing a hundredweight or more. The fresh exudation of the trees is of no value. The value of kauri in varnish making is due to the large amount of oil it will take up, and to the fact that it can be worked into a varnish at a lower temperature than any other copal. The trade in it amounts to about half a million pounds sterling per annum.

Kazen (*Mining*). A Cornish term for a sieve.

Keel Moulding (*Architect.*) A moulding used in the Early English and Decorated periods. In section it resembles the keel of a ship or an ogee arch. It consists of a pointed bowtell with a slight sinking on each side of the point or arris. *See* BOWTELL, ROLL MOULDING, *and* SCROLL MOULDING.

Keen's Cement (*Build.*) A cement or plaster capable of being worked to a very hard and highly polished surface. It is obtained by soaking plaster of Paris in alum water after a first calcination; it is then put again into the kiln, reburnt, and ground. It is especially useful on sharp angles of walls and on walls which have to be painted.

Keep (*Archæol.*) *See* DONJON.

Keeper (*Elect.*) A piece of soft iron placed across the poles of magnets; it completes the magnetic circuit and decreases the demagnetising effect.

—— (*Eng.*) The lower part of the bearing in the axle box of a railway vehicle; there is no force exerted by the axle on this part of the bearing during steady running.

Kefir (*Foods*). *See* KEPHIR.

Kelp (*Chem.*) The ash obtained by burning seaweed, especially deep-sea weed. It is used in the preparation of iodine (*q.v.*) Instead of burning it, the weed may be extracted with sodium carbonate solution, and the liquid obtained treated with hydrochloric acid. The resulting liquid, neutralised with caustic soda and evaporated, gives a residue of salts called kelp substitute; it contains all the iodine, and is used for the preparation of iodine.

Kelp Substitute (*Chem.*) *See* KELP.

Kentish Coal. *See* COAL.

Kentish Rag (*Build.*) A stone used for rubble walling. *See* BUILDING STONES.

Kentledge (*Eng.*) The heavy material (stones, scrap iron, etc.) used to form a counterbalance weight in a balance crane.

Kephir *or* **Kefir** (*Hygiene*). Fermented cow's milk; a modern substitute for KOUMISS (*q.v.*) It is more easily digested and absorbed than the original milk, and is used medicinally. The process of fermentation is a double one; both lactic acid (*q.v.*) and alcohol are produced, though the amount of each is very small.

Kepler's Laws (*Astron.*) FIRST LAW: The orbit of a planet is an ellipse, the sun being in one focus. SECOND LAW: The radius vector (the line joining the sun to the planet) sweeps out equal areas in equal times. THIRD LAW: The squares of the Periodic Times of the planets are proportional to the cubes of their mean distances from the sun.

Kerargyrite (*Min.*) A synonym for HORN SILVER (*q.v.*)

Keratin (*Zool.*) An organic substance which is found in horn, nails, and in the cells of the epidermis when it assumes a horny texture, *i.e.* when pressed out by the growth of younger cells.

Kerf (*Carp. and Join.*) The cut made by a saw.

Kermesite (*Min.*) An oxysulphide of antimony, $2Sb_2S_3$, Sb_2O_3. Antimony = 76·34, oxygen = 4·73, sulphur = 18·93 per cent. Monosymmetric. Crystals usually acicular. Also in radiating masses. Saxony Bohemia, Hungary, France, etc.

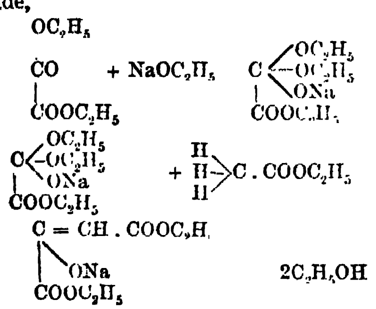
Kern (*Typog.*) That part of a letter which overhangs its body or shank, more generally met with in italic type, owing to the slope of the characters.

Kerr's Phenomena *or* **Kerr Effects** (*Phys.*) Kerr discovered that a transparent dielectric like glass or carbon disulphide becomes doubly refracting under the influence of an electrostatic strain. Terminals were fixed in holes drilled in a slab of glass and connected to a powerful electric machine, and the glass was placed between crossed Nicol prisms, so that the light passed through it at right angles to the lines of electric force. On working the machine the dark field became coloured. Kerr afterwards discovered a magnetic effect on polarised light. When plane polarised light is reflected from the polished surface of the pole of a powerful magnet, the plane of polarisation is rotated: the rotation produced by a positive pole is in a clockwise direction; that produced by a negative pole is in the reverse direction. The phenomena is, however, complicated, and depends upon the relation of the plane of polarisation to the plane of incidence. This effect is one of the various experimental results which connect light with electro-magnetic phenomena.

Kerosene (*Chem.*) That fraction of American petroleum boiling between 150° and 300°, and consisting of paraffin hydrocarbons (*q.v.*) containing from 10 to 16 atoms of carbon. It is usually purified by shaking in succession with sulphuric acid and caustic soda, distilling it, and collecting for burning purposes the fraction coming over between the above temperatures.

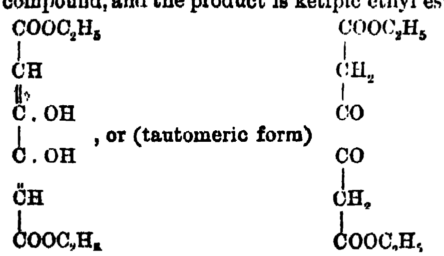
Ketipic Acid (*Chem.*) *See* KETIPIC ESTER.

Ketipic Ethyl Ester (*Chem.*)
$$\begin{array}{l}COCH_2COOC_2H_5\\ |\\ COCH_2COOC_2H_5\end{array}$$
A crystalline solid; melts at 77°, soluble in alcohol. Ferric chloride imparts a deep red colour to its solution in alcohol. Forms an osazone (*q.v.*) On hydrolysis it yields the unstable ketipic acid, which readily loses $2CO_2$ and forms diacetyl—a diketone (*q.v.*) Ketipic ethyl ester is obtained as follows: Act upon ethyl oxalate and ethyl acetate with sodium ethoxide,

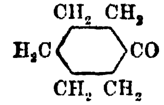


Acidify, and the product is $\begin{array}{l}C.OH : CH.COOC_2H_5\\ |\\ COOC_2H_5\end{array}$

(ethyl oxalacetate). Repeat the whole process on this compound, and the product is ketipic ethyl ester,

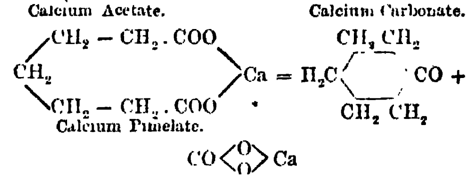


Ketones (*Chem.*) Compounds of the formula $R - CO - R'$, where R and R′ are alkyl groups or other hydrocarbon residues which may be the same or different, are called ketones. Examples are acetone CH_3COCH_3, and acetophenone $CH_3COC_6H_5$. When R and R′ are substituted alkyls or hydrocarbon residues, the compounds have still the ketone character, but have also the character of the substituting groups superimposed on the ketone character; *e.g.* ethyl acetoacetate, $CH_3CO.CH_2COOC_2H_5$, has the ketone character, but this is modified by the presence of the group $-COOC_2H_5$. The ketone group may also occur in a ring, giving rise to what are called cyclic ketones; *e.g.*



which is called cyclohexanone (*see* NOMENCLATURE) or ketohexamethylene. The ketone group may occur more than once in a compound, giving diketones (*q.v.*), etc. Among the benzene compounds there occurs a class of ketones of such distinctive properties that they have been given a special name—quinones (*see* QUINONES). The ketones may be obtained by many methods; *e.g.* (1) Heating the calcium salts of acids—

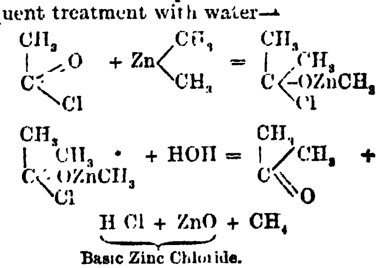
$$\begin{matrix}CH_3COO\\ CH_3COO\end{matrix}\!\!>Ca = CH_3COCH_3 + CO\!<\!\begin{matrix}O\\ O\end{matrix}\!>Ca$$
Calcium Acetate. Calcium Carbonate.



(2) Oxidation of a secondary alcohol—

$$CH_3.CHOH.CH_3 + O = CH_3.CO\ CH_3 + H_2O$$
Secondary Propyl Alcohol.

(3) Action of zinc alkyls on acid chlorides and subsequent treatment with water—



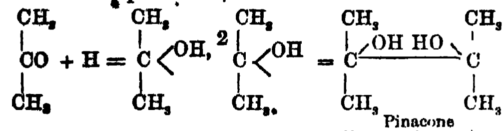
(4) From nitriles by the action of an alkyl iodide in presence of magnesium, the best yields being obtained with aromatic nitriles (*e.g.* benzonitrile with ethyl iodide gives an 80 per cent. yield of the ketone)—

$$C_6H_5CN + C_2H_5I + Mg = \begin{matrix}C_6H_5\\ C_2H_5\end{matrix}\!\!>C = N.MgI$$
Benzonitrile.

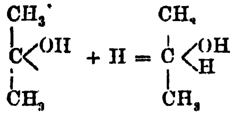
$$2\begin{matrix}C_6H_5\\ C_2H_5\end{matrix}\!\!>C : NMgI + 4HOH = 2\begin{matrix}C_6H_5\\ C_2H_5\end{matrix}\!\!>CO +$$
$$2\,NH_3 + Mg\,(OH)_2 + MgI_2$$

(5) From β-ketonic acids by hydrolysis of the ester by alcoholic caustic potash (*see* ETHYL ACETOACETATE). Important examples of ketones are acetone, acetophenone, camphor; and of com-

pounds containing ketone groups, ethyl acetoacetate and lævulose (*see these*). (6) Aromatic ketones may be obtained from benzene by the action of an acid chloride in presence of aluminium chloride (*see* ACETOPHENONE). The chemical reactions of the ketones are : (1) On reduction they yield secondary alcohols and pinacones,



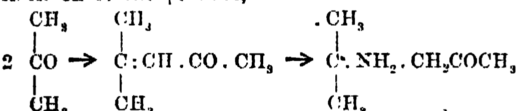
Pinacone
Tetramethylglycol.



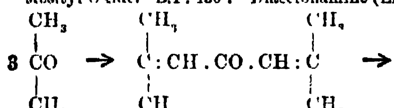
(2) On oxidation they yield acids with a smaller number of carbon atoms in the molecule than the original ketone; *e.g.* ethyl propyl ketone, $CH_3CH_2COCH_2CH_2CH_3$, yields acetic, propionic, and butyric acids. (3) Phosphorus pentachloride replaces the oxygen by two atoms of chlorine,

$$CH_3COCH_3 \rightarrow CH_3CCl_2CH_3$$

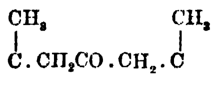
(4) Ammonia causes condensation, and then adds itself on to the product,



Mesityl Oxide. B.P. 130°. Diacetonamine (Liquid).

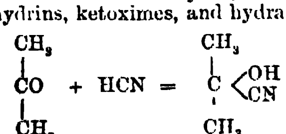


Phorone. M.P. 28°.

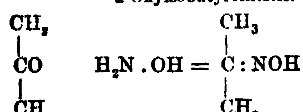


Triacetonamine. M.P. 40°

(5) With hydrocyanic acid (HCN), hydroxylamine (H_2NOH), and phenylhydrazine ($H_2N.NHC_6H_5$) the ketones behave like the aldehydes, forming respectively cyanhydrins, ketoximes, and hydrazones—

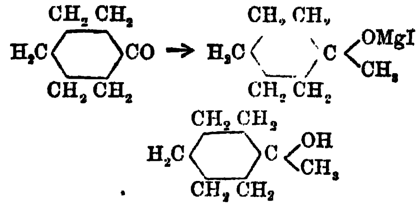


a-Oxyisobutyronitrile. B.P. 120°.



Acetoxime. M.P. 60°.

(6) Those ketones which contain a methyl group unite directly with sodium hydrogen sulphite just as the aldehydes do. (7) Ketones undergo condensation; *e.g.* hydrochloric acid causes two molecules of acetone to lose one molecule of water and form mesityl oxide (*see* 4); three molecules of acetone to lose two molecules of water and form phorone (*see* 4). Boiled with sulphuric acid, acetone condenses to mesitylene (*q.v.*) (8) Ketones, especially cyclic ketones, yield tertiary alcohols when boiled with magnesium and an alkyl iodide in ethereal solution, and the product of the reaction acidified with dilute acid :



Ketose (*Chem.*) A sugar which contains the ketone group is called a ketose—*e.g.* lævuolose (*q.v.*)

Ketoximes (*Chem.*) *See* KETONES, *also* OXIMES.

Kettledrums (*Music*). *See* MUSICAL INSTRUMENTS (PERCUSSION).

Kettlestitch (*Bind.*) The chain stitch made at the head and tail of a book when the sections are being sewn together, prior to binding, in order to keep them firm.

Keuper (*Geol.*) The uppermost division of the Trias or Upper New Red. In Britain it consists of a small thickness of sandstone, prevalently red in colour, and an overlying series of red marls, which range to as much as eight hundred feet in thickness where they are most fully developed. Deposits of rock salt, and also of gypsum, occur in these marls. The Keuper series has been formed under continental conditions, and in an arid climate, at the bottom of inland lakes.

Key (*Bind.*) A small metal implement used to secure one end of a band to the base of a sewing press, the other end being attached to a loop formed of cord on the adjustable bar running across the press. *See* BANDS; *and* SEWING PRESS *under* BOOKBINDING.

—— (*Eng., etc.*) (1) A wedge shaped piece of iron or other material used for fixing a joint, especially the wedge by which a wheel is fixed on its axle. (2) A tool used for turning a nut or other loose part of some machine or structure.

—— (*Music*). I. A system of notes in connection with one certain note called the "Tonic," or keynote, from which the key is named. This system includes the seven notes of the major diatonic scale, together with five chromatic notes, *viz.* the flattened 2nd, 3rd, 6th, and 7th, and sharpened 4th of the diatonic scale. The technical names of the seven diatonic notes are : (1) Tonic or keynote. (2) Supertonic (above the tonic). (3) Mediant (midway between tonic and dominant). (4) Sub-dominant (the *under*-dominant, being a fifth below the tonic just as the dominant is a fifth above the tonic) (5) Dominant (governing note). (6) Sub-mediant (the *under*-mediant, being midway between the sub-dominant (under-dominant) and the tonic. (7) The leading note (from its tendency to lead to the tonic, below which it is only a semitone), also called sub-tonic (under the tonic). [8. Tonic or keynote, being replicate of 1.] Starting from C, the twelve notes of the key are :

These notes with the tails turned down form the major scale; those with the tails turned up, the minor scale. The whole series form the diatonic chromatic scale. II. That part of the mechanism of keyed instruments on which the finger rests. It is, strictly speaking, a lever, which in the case of the pianoforte raises a hammer, and in the case of the flute, etc., opens or closes the sound holes.

Key (*Plastering*). The portion of the plaster that squeezes through the laths of a ceiling or partition; any holes or roughness that the plaster can hang to.

Key Bed *or* **Way** (*Eng.*) The grove cut in a shaft or the hub of a wheel, into which the key is driven.

Keyboard (*Music*). The set of keys on instruments played by means of keys. On organs the keyboards are spoken of as "manuals," to distinguish them from the keyboard played with the feet, called a pedal board.

Key Harmonica (*Music*). *See* MUSICAL INSTRUMENTS (PERCUSSION).

Keyhole Saw (*Carp.*) A narrow saw having a handle at one end only, and somewhat resembling a very narrow handsaw; used for cutting out small pieces of wood such as those removed in forming the central part of a keyhole. A hole is bored at each end of the keyhole, in which the point of the saw can be inserted.

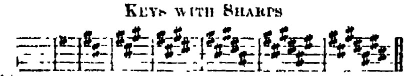
Keyless Work (*Watches*). The mechanism enabling one to wind and set a watch by turning the pendant knob or "button," instead of having to use a separate key.

Keynote (*Music*). *Also called* TONIC. The note from which the scale begins, and by which it is named.

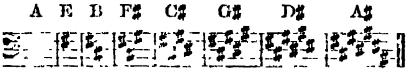
Key Seating (*Eng.*) A KEY BED (*q.v.*)

Key Signature (*Music.*) The sharps or flats belonging to the key placed at the beginning of a piece of music between the clef and the time signature to show that every note of their respective names, throughout the piece, is to be so affected unless contradicted. The sharps and flats are called ESSENTIAL sharps and flats, and are written as follows:

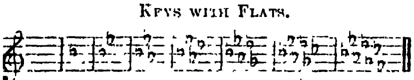
KEYS WITH SHARPS



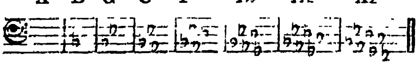
Major Key.	C	G	D	A	E	B	F♯	C♯
Minor Key.	A	E	B	F♯	C♯	G♯	D♯	A♯



KEYS WITH FLATS.



Major Key.	C	F	B♭	E♭	A♭	D♭	G♭	C♭
Minor Key.	A	D	G	C	F	B♭	E♭	A♭



It will be seen that in keys with sharps the major keynote is always one note above the last sharp in the signature, and in keys with flats it is always the last flat but one in the signature. The keys of C major and A minor having no sharp nor flat are often spoken of as the "open" signature. It will be noticed that the minor keynote is always three semitones below the major keynote. A simple rule to determine whether a piece is in the major or minor key is: Assume that it is major, then see if the dominant is unaltered throughout the piece or section. If unaltered, it is major; but if that note be raised in the majority of times it occurs, then it is in the minor key.

Keystone (*Architect.*) The stone which occupies the centre of the crown of an arch. *See* ARCH.

Kibble, Kibbal (*Mining*). A vessel used for drawing up materials from a mine; a bucket, barrel, etc.

Kick (*Build.*) The depression or FROG in the surface of certain kinds of bricks.

Kidney Ore (*Min.*) A variety of HÆMATITE (*q.v.*) so called from its resemblance to a lobed kidney.

Kieselguhr. A fossil deposit consisting of the silicified valves of the vegetable organisms known as DIATOMS (*q.v.*) It is used in making dynamite (*q.v.*)

Kieselguhr Bricks. *See* BRICKS.

Killas (*Geol.*) A Cornish name for the country rock, mainly of sedimentary origin, in which the metalliferous veins occur. The name is applied irrespective of the geological age of the rock. A large part of the killas may be of Devonian age; some is certainly Carboniferous; and part may pertain to the Proterozoic System. Most of the "killas" of Devonshire and Cornwall has been dynamically metamorphised.

Killed Spirits. A solution of zinc chloride used in soldering; scrap zinc is added to hydrochloric acid until the acid is neutralised or "killed."

Kiln. A furnace in which ore or some other substance is placed in order to be strongly heated, but not fused; *e.g.* in glass manufacture a square or rectangular annealing oven heated on both sides, used chiefly for annealing large articles. When full the kiln is closed, and by allowing the fires gradually to become extinct, the articles are more thoroughly annealed than by passing them down the lear. *See* BRICKS, GLASS MANUFACTURE, POTTERY AND PORCELAIN, BISQUE OVEN, GLOST OVEN, ENAMEL KILN, *etc.*

Kilogram. *See* WEIGHTS AND MEASURES.

Kilometre. *See* WEIGHTS AND MEASURES.

Kinematics. The science dealing with the motion of bodies, apart from the forces which produce the motion.

Kinetic Energy. The energy which a body possesses in virtue of its motion. If m be the mass, and v the linear velocity of a body, then the kinetic energy is $\frac{1}{2} m v^2$. In the case of a rotating body, if K be its MOMENT OF INERTIA (*q.v.*) and ω its angular velocity, the kinetic energy is $\frac{1}{2} K \omega^2$.

Kinetic Friction. *See* FRICTION, KINETIC.

Kinetic Theory of Gases (*Phys.*) The theory whereby the known physical properties of gases are deduced from the assumption that a gas consists of many separate molecules, each having a finite mass and velocity, and obeying the ordinary laws of motion.

King Bolt (*Carp and Join.*) An iron rod, taking the place of the king post in a truss. *See also* ROOFS.

Kingcloser. A brick cut lengthwise, showing $2\frac{1}{4}$ in. one end and $4\frac{1}{2}$ in. the other.

King Post (*Carp. and Join.*) The central vertical timber in a trussed roof or in a partition. *See also* ROOFS.

King Rod (*Build.*) An iron rod used in place of the king post in an iron roof. *See* KING BOLT *and* ROOFS.

Kings of Arms. The chief officers of the Heralds' College. They are "Garter," "Clarenceux," and "Norroy" for England; "Bath," "Lyon," and "Ulster" for Wales, Scotland, and Ireland respectively.

Kino. A dark red astringent jelly-like juice used in medicine and tanning. Obtained from incisions made in the trunks of various trees and shrubs in tropical and sub-tropical regions. The chief varieties are official or Malabar Kino (India and Ceylon), and Australian or Eucalyptus Kino. It resembles CATECHU (*q.v.*).

Kiosk *or* **Kiosque** (*Architect.*) A small structure, generally polygonal or circular in construction, with open sides, and surmounted by a dome-shaped or tent-shaped roof carried on pillars. Used as a band stand, summer house, etc.

Kip Leather. Leather made from Kip hides, which are the skins of yearling cattle grown in India.

Kirchoff's Hypothesis (*Astron.*) The hypothesis which explained the origin of the dark lines in the solar spectrum. When the light from an incandescent body passes through the same substance in a state of vapour, the coloured bands become replaced by dark or absorption lines.

Kirchoff's Laws (*Elect.*) FIRST LAW: At a point where any number of conductors carrying currents meet, the algebraic sum of all the currents flowing towards the point is equal to the sum of the currents flowing away from the point. SECOND LAW: If any closed circuit be made up of conductors of resistance r_1, r_2, r_3, etc., and if the currents in these conductors are c_1, c_2, c_3, etc., then the algebraic sum $c_1r_1 + c_2r_2 + c_3r_3 +$ is equal to the electromotive force acting in the circuit. This law is of great use in the calculation of currents in conductors forming a number of different closed circuits, *e.g.* the WHEATSTONE BRIDGE (*q.v.*)

Kish (*Chem.*) A name given to the carbon which separates from melted pig iron when silicon or highly silicious iron is added to it. When a molten mass of grey pig iron is allowed to cool *slowly* (as in a foundry ladle) a scum of graphitic carbon (*q.v.*) separates and collects on the surface.

Kist. *See* CIST.

Kit-Cat (*Paint.*) A term applied to a portrait on canvas rather less than threequarter length (36 by 28 in.), in which the hands are shown. The term arose from the fact that Sir Godfrey Kneller painted a series of portraits of members of the *Kit-Cat Club* on canvases of those dimensions to fit the walls of a room in Tonson, the publisher and bookseller's residence, Barn Elms, Putney. Addison and Steele were amongst the members of the club.

Kitchener *or* **Kitchen Range.** A kitchen stove the grate portion of which can be either used as an open or a closed range. It is provided with an oven and a boiler and with the necessary flues for heating them. The top of the stove, known as the hot plate, is used for heating saucepans, etc.

Kite (*Meteorol.*) An instrument for "sounding," or taking observations in, the air Of various shapes and sizes. It is raised in the air by the force of the wind pressing against its surface, and is held steady by means of a cord.

Kite Winch (*Meteorol.*) A winch used for paying out the line or winding it up during the flight of a kite.

Klemm's Leather. *See* CROWN LEATHER.

Knee (*Carp. and Join.*) A convex curve, the reverse of a RAMP (*q.v.*)

Kneeler (*Build.*) A stone placed either at the base of the slope of a gable or at a higher level; its base is horizontal, while one face is usually cut to the same angle as the gable. It serves to relieve a part of the diagonal thrust.

Knib (*Typog.*) A small projection at one end of a setting rule to enable it to be more easily lifted from the composing stick when the line of type has been set.

Knife Edges. Sharp edges of steel, agate, or other hard material, on which a lever turns; used in balances, weighing machines, etc.

Knife File (*Eng.*) A thin, sharp edged file.

Knitting Frame, *or* **Loom** (*Textile Manufac.*) A machine for the knitting of warp threads into a wearable fabric. It may be a straight-bar or circular loom. The fabric possesses the same structure as that due to the ordinary process of knitting.

Knocking (*Eng.*) A noise heard in the cylinder of a pump or engine, due to a loose part or the accumulation of fluid (gas, steam, or water) at the end of the stroke. The term is often applied to noises due to various other defects in machinery.

Knocking-Down Iron (*Bind.*) An oblong rectangular piece of iron with a leg on one side, by means of which it is secured in the lying press. The upper surface, which is flat, is used as a support when beating the slips in the boards after they are laced in, so that they may be imperceptible when the boards are covered.

Knop Yarn (*Textile Manufac.*) Yarn on the surface of which are formed at intervals small knops or lumps, which may be of one or several colours. The process of producing this yarn is known as "knopping," and is done on the twisting frame.

Knots (*Her.*) Heraldic badges, made of intertwined cords, borne by different families.

Knotter (*Paper Manufac.*) An appliance for removing knots and mechanical impurities from pulp.

Knotting (*Dec.*) A preparation of shellac used for covering knots in wood before being painted. *See* HOUSE PAINTING.

Knuckle (*Build.*) The joint of a hinge.

Knuckle Joint (*Eng.*) A hinged joint between two rods; one possesses an eye or loop, fitting into a forked projection on the other rod; a pin passes through the eye, forming an axis, about which the two members can turn.

Kohlrabi (*Botany*). Like the cabbage, broccoli, and kale, this plant is a cultivated variety of *Brassica oleracea* (order, *Cruciferæ*).

Kola (*Botany*). An African plant, *Cola acuminata* (*Sterculiaceæ*), whose seeds, known as Kola nuts, are used in medicine, having the power of sustaining fatigue.

Kollergang (*Paper Manufac.*) *See* EDGE RUNNER.

Kombé (*Botany*). The important drug STROPHANTHIN is obtained from the ripe seeds of *Strophanthus kombe* (*Apocynaceæ*), which are used in Central Africa as an arrow poison.

Koumiss *or* **Kumiss**. An alcoholic beverage resulting from the fermentation of mare's milk, commonly used by many nomadic tribes in Asia, especially by the Tartars. Sometimes used dietetically in this country.

Kr (*Chem.*) The symbol for KRYPTON (*q.v.*)

Krio Sphinx (*Architect.*) A carved figure having the body of a lion and the head of a ram. *See* SPHINX *and* ANDRO SPHINX.

Krokidolite (*Min.*) *See* CROCIDOLITE.

Krypton, Kr. (*Chem.*) Atomic weight, 81·8. A gas without chemical reaction. It has a monatomic molecule; a characteristic spectrum; boils at $-151{\cdot}7^{\circ}$ It occurs in the atmosphere to the extent of 1 part in 7,000,000. It is obtained by fractional distillation of liquid air.

Kundt's Experiment (*Sound*). If a fine powder be placed in a tube containing a gas in which STATIONARY WAVES (*q.v.*) of sound are being produced, the powder collects in heaps at the LOOPS (*q.v.*); from the position of these heaps we can determine with fair accuracy the distance from one loop to the next, and hence the wave length (*q.v.*) of the sound in the gas in the tube. From the wave length we can calculate the velocity of sound in the gas.

Kupfernickel (*Min.*) Arsenide of nickel, NiAs. Nickel=44·1, arsenic=55·9 per cent. Hexagonal, but usually massive, with a coppery colour, whence the name. It is used as an ore of nickel. From Cornwall, Linlithgowshire, Wigtonshire, Saxony, Bohemia, many places in Scandinavia, N. and S. America.

Kyanising (*Eng., Build.*) Soaking timber in a solution of corrosive sublimate, $HgCl_2$, in order to preserve it.

Kyanite (*Min.*) A silicate of aluminium, Al_2O_3, SiO_2. Silica=37, alumina=63 per cent. Triclinic, occurring in bladed crystals in metamorphic rocks. Pale blue to white. Banffshire, Aberdeenshire, Perthshire, Shetland, Ireland, Switzerland, Tyrol, the United States, etc.

Kylin (*Art.*) A mythical animal often depicted on Chinese and Japanese porcelain. Sometimes known as the Chinese Unicorn.

L (*Phys.*) The symbol for LATENT HEAT (*q.v.*)

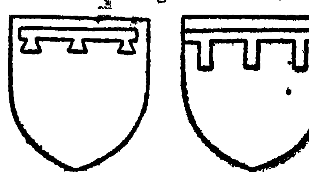
La (*Chem.*) The symbol for LANTHANUM (*q.v.*)

La, Lah (*Music*). The sol-fa name for A in the fixed Do system; and for the sixth degree of the scale (submediant) in the movable Do system.

Labarum (*Archæol.*) (1) The Roman imperial standard as altered by Constantine the Great after his conversion to Christianity, certain Christian symbols being incorporated on it. (2) A general term for a banner or standard.

Label (*Architect.*) *See* HOOD MOULD.

—— *or* **File** (*Her.*) A mark of cadency used to distinguish the eldest son during the lifetime of his father. It consists of a bar with three points placed across the paternal shield, in chief. In the case of younger sons the paternal shield is differenced by the following additions:



MODERN FORM. OLD FORM.

the second son uses a crescent; the third son a mullet; the fourth son a martlet; the fifth son an annulet; the sixth son a fleur-de-lys; the seventh son a rose; the eighth son a cross moline; the ninth son a double quatrefoil. In the case of royalty the label is employed by all sons, but the second and younger sons bear the label differenced.

Labiatæ (*Botany*). The natural order *Labiatæ* includes a large number of plants which are valued for the essential oils they contain. A common and fairly typical example is the WHITE DEAD NETTLE (*Lamium album*). Among the plants of this order are the LAVENDER (*q.v.*), SWEET BASIL (*Ocymum basilicum*), MINT (*Mentha*), MARJORAM (*Origanum*), THYME (*Thymus*), ROSEMARY (*Rosmarinus officinalis*), BALM (*Melissa*), HOREHOUND (*Marrubium*), *Pogostemon Patchouli*, which yields OIL OF PATCHOULI, and many others.

Laboratory. (1) A place in which experimental work and investigation in natural science are carried on. (2) Another term for the "hearth" of a reverberatory furnace, *i.e.* the part in which the effective work of the furnace is performed.

Labradorite (*Min.*) A calcium aluminium sodium silicate; approximate composition, silica = 52·9, alumina = 30·3, lime = 12·3, soda = 4·5 per cent. Triclinic. It is one of the felspars. Grey, brown, greenish, sometimes colourless. It shows a fine play of colour in certain directions, and is cut as an ornamental stone. It is of very wide distribution in basic volcanic rocks.

Laburnum. *See* WOODS.

Lac (*Botany*). A resinous exudation from the branches of a number of trees such as *Ficus indica* and *F. religiosa* (order, *Moraceæ*); *Butea frondosa* (order, *Leguminosæ*); *Croton lacciferus* (order, *Euphorbiaceæ*). It is caused by the punctures of a small insect (*Cossus ficus*). *See also* SHELLAC.

Laccolite (*Geol.*) A term originally applied to those occurrences of intrusive rocks in which the eruptive rock displaces its own volume of the rock invaded, and thus, as it were, lifts the whole of the overlying country rock on its back. One or two such instances have been seen abroad; but most of the intrusive masses to which this name has been applied are nothing more than sills occurring in the usual manner, *i.e.* without any such upward arching of the country rock above. The term may well be dispensed with.

Lace Hand and Machine Made. "The earlier laces were plain braids," and were made by "unroving the edges of woven material and plaiting or knotting the fringe so formed" into a reticulated border. This was one of the earliest forms of ornamentation. Further developments were the introduction of a braid with a toothed edge called DENTELLE and CUTWORK,

the latter a method of ornamentation, which was produced by arranging a series of threads upon a frame and interlacing them by the aid of needle and thread, thus forming a net or ground upon which various objects cut out of woven material could be embroidered. Every draper's shop window gives ample evidence of the survival—or revival in a modern form—of this art, by the display of a multiplicity of articles, both for home and personal adornment, composed of fabrics of the most diverse character superimposed upon each other, *e.g.* a design, worked by the aid of the sewing machine, through two fabrics. Upon the superfluous material of the imposed fabric being cut away, effects are evolved artistic, unique, or peculiar. A similar effect to cutwork was attained by the method known as DRAWNWORK, produced by drawing a design upon woven fabric and then carefully cutting certain threads of both weft and warp at regular intervals in the interspace between the various objects of the design; the cut threads were then carefully drawn out, thus leaving reticulated openwork which could afterwards be more firmly secured by the aid of the needle and to the fancy of the worker. These methods were the fashionable employment for ladies of the period about 1587. There are two descriptions of lace, "point" and "pillow." Real POINT LACE is made entirely by the aid of the needle, upon a parchment pattern, each loop or stitch being so worked as to hold the preceding stitch in position. The Italians claim to have invented it, but they probably derived the art of fine needlework, of which lace is a development, from the Greeks. Much proficiency in the art had been attained by 1626, and a great development in 1665 by Colbert's establishment of the POINTS OF FRANCE. The chief centres of manufacture were Venice, Milan, Genoa, and Brussels. The nuns also were amongst the principal makers, being very expert in the production of the extremely fine flaxen thread so essential to the making of high class lace. It is mainly owing to the fineness of this thread that BRUSSELS LACE (*q.v.*) owes its beauty of appearance. PILLOW LACE is made upon a parchment pattern, but quite a number of threads enter into its composition, each thread having a separate source of supply called a bobbin; and, being similar in shape to an ordinary lead pencil, they can be twisted or otherwise manipulated with ease. The parchment pattern being secured to the pillow or cushion and the threads to pins, stuck at suitable intervals into the cushion, the worker's hands are free to make the necessary movements. There is a considerable quantity of "lace" that is designated SEMI-REAL LACE produced by modern methods. It is a composite article, machine made braids being utilised to form the more substantial outline of the pattern, the "fillings" being wrought by the needle and also by adventitious aids. Very effective articles are produced, Luxeuil being one of the principal sources of manufacture. Most laces take their name from the place where they were first made, or that were noted for the excellence of their production, and many laces differ much more in name than in appearance. The chief exception to this rule is GUIPURE, which takes its name from a made up cord composed of some inferior material, such as cotton wrapped round or plated with a more valuable article, *e.g.* gold thread or silk. This principle produces, not only a thicker thread, but a thread of an entirely different appearance, and is used to form the raised pattern. Any lace therefore that contains raised outlines attained by this or similar methods may be called "Guipure": thus we find "Spanish Guipure," etc., and also various "made up" names as "Guipure d'art." The Germans claim the invention of pillow lace, and Barbara Uttmann, of St. Annaberge, as the medium, about 1560.—W. H.

Lace Machine. Ignoring experiments, the first machine for producing lace net as a practical and commercial success was invented by John Heathcote, 1809-11; and though many mechanical imperfections have been eliminated and improvements developed, the fundamental principle remains the same in the modern machine of to-day. The object to be attained is to twist one series of threads around a neighbouring and alternating series. This is accomplished by dividing the threads that will eventually compose the fabric into two systems, one called the "warp," where each thread has a common source of supply (the warp beam), and the other called the "bobbins," which, though numerically the same, have each an independent source of supply. The continuity of this latter system of threads is thus broken below receptacles called the "carriages," each of which contains an independent bobbin. These carriages (with the bobbins they contain) are so attenuated, so slim, that the whole system is able to pass simultaneously between neighbouring warp threads. A slight lateral movement of the warp threads at right angles to the plane of the carriages (to the right when the carriages swing in one direction, and to the left at the return movement of the carriages) causes warp thread and bobbin thread to twist together. A continuation of these movements simply forms a series of twisted pillars, composed of one bobbin and one warp thread twisted together, and having no connection with any neighbouring pair of threads; but if at certain regular intervals a more extended lateral movement is communicated to the guide bars that control the warp threads (say over two carriages instead of only one), then community is at once established and a web of net begins to be formed, the description of net being dependent upon the character of the movement communicated to the warp threads. It requires two "motions" or movements of the carriages to form one complete twist, and by reference to fig. 1 it will be readily understood that it has taken six to and fro movements of the carriages to form the first three twists represented in the upper portion of the drawing; it will also be realised that so long as this limited amount of movement is continued, only twisted pillars would be formed, as previously mentioned; but the seventh movement shows the warp thread as having been moved to the right behind two bobbin threads; the eighth movement, to the left over one bobbin; the ninth movement, to the right under one bobbin; the tenth movement, to the left over two bobbins; the eleventh movement, to the right under one

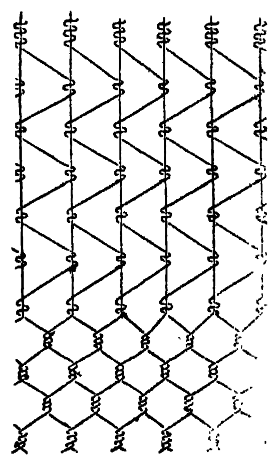


FIG. 1.

bobbin: the twelfth movement, to the left over one bobbin, after which it is all repetition in the same order. Up to this point it has been assumed that the bobbin thread is a straight line, as represented in the drawing; and on paper this is perfectly correct, but it must be remembered that the bobbin threads form a system of threads to themselves, each thread from an independent source; and the tension upon each thread is controlled by a flexible spring, that impinges upon the bobbin: these springs are adjusted to give a uniform tension, as far as possible. The warp threads (the other system) all come from a common source, and one controlling influence affects them collectively. This controlling influence generally takes the form of a cord passed around a collar on the end of the warp beam. To the end of this cord a weight or spring is attached, though other mechanical devices are used. It will be obvious that should the weight or tension upon the warp exceed that upon the bobbins, the exact reverse of what is represented in the drawing would occur—*viz.* the warp would pull straight and the bobbin would lie across. Neither of these conditions would contribute to success in net making; it is the happy medium that is required—just sufficient tension upon the warp to cause bobbin and warp to adapt themselves to each other, as shown in the last three meshes represented, which depict the formation of MECHLIN NET, also known as MALINES and TULLE. There are three descriptions of twist lace machines, but one principle obtains in them all. The principle is that of a swinging pendulum, all the machines being built to a certain diameter of circle, generally 12 to 14 in. It is in the lower half of the circumference of this circle that the carriages, properly controlled, swing, like so many pendulums, and with similar rhythm, at a speed of about 120 swings or "motions" per minute. The machine invented by John Heathcote is best adapted for making plain net, either Brussels or Mechlin. Owing to difficulties originally encountered in procuring carriages of sufficient thinness he found it necessary to place the carriages in two rows or tiers one behind the other, and though the principle was adopted in the first instance as an extremity, it was found so efficient for the making of traverse net that it has never been superseded, and still obtains in the most modern machines. Fig. 2 shows the principle, the carriages being actuated upon the rolling locker method. Though the double tier principle has not been departed from for plain net machinery, the original idea of a single tier machine was never lost sight of, and in 1813 John Lever invented his single tier machine, where there are as many carriages in one row as in two rows in the plain net machine, each carriage being proportionally thinner. Though in the first instance it was intended to make, and did make, plain net, it was soon found that its proper function was the making of fancy laces, nets, edgings, insertions, and millinery laces generally. Fig. 3 shows the essential principle of this machine. The third machine in use, though the same in principle, is really a development comprising some of the features of both the above machines, advantage being taken of those that would best add to its capacity for making lace curtains, where speed and facilities for producing breadth of design are the qualities chiefly required. —W. H.

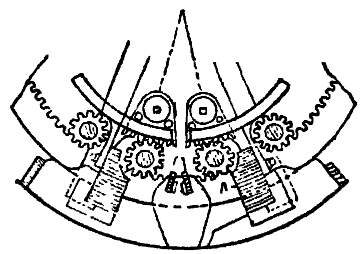


FIG. 2.

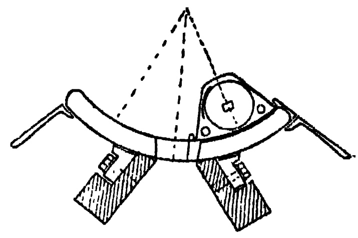


FIG. 3.

Lachrymatory (*Archæol.*) The name given to a small vase or phial, generally elongated in form, found in ancient Roman tombs. The name implies that they were intended for holding tears, but it is more probable that they were intended for other purposes.

Lacing (*Eng.*) The union of the ends of leather belting by means of thongs of leather passed through pierced holes.

Lacing Cord (*Lace Manufac.*) Cotton cord or braid made upon the "dolly" or braiding machine, for lacing Jacquards together.

Lacing Course (*Build.*) A course of bricks bonding the rings or successive courses of an arch.

Lacing In (*Bind.*) Passing the ends of the bands or cords to which the book is sewed through holes made in the boards. When passed through, they are hammered well into the boards, thus attaching the boards to the book. *See* BANDS, BOARDS, *and* KNOCKING-DOWN IRON.

Lac Insect (*Zool.*) *Coccus ficus*, belonging to the same tribe as the Cochineal insect (*q.v.*); perforates the bark of tropical trees, causing an exudation of resin (LAC). As SHELL-LAC the resin is used in making varnishes, sealing wax, and lacquer.

Lacmoid (*Chem.*) Probable constitution,

$$N\begin{cases} C_6H_4(OH)_2 \\ C_6H_3OH:O \end{cases}$$

Reddish brown, shining, amorphous grains; soluble in alcohol, acetic acid, and less soluble in ether and in water; insoluble in chloroform and benzene. To prepare it, resorcin (100 grs.), sodium nitrite (5 grs.), and water (5 c.c.) are gradually heated to 110°; when the reaction is over, the heating is continued at 115° to 120°; ammonia is given off, and the product becomes blue in colour; water is added, then hydrochloric acid till the blue colour is changed to red. The precipitate is filtered off and washed with a little water, and dried at 100°. In dilute solution in alcohol (·2 gr. in 100 c.c.) it forms an important INDICATOR (*q.v.*); acids turn it red, alkali blue. Carbonic acid affects it, also nitrous acid, and sulphuretted hydrogen decolourises it. Salts of the alkaline earths do not affect it. Lacmoid paper can be used to titrate carbonates and sulphides, also chromates (normal chromates turn it blue, free chromic acid red).

Lacquer (*Dec.*) It is by no means easy to distinguish between a lacquer and a varnish; in fact, the distinction is more conventional than real. A lacquer generally means a spirit varnish, and especially those in which shellac is the chief solid

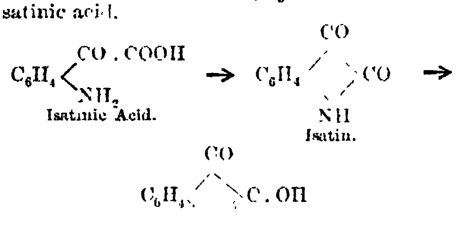
ingredient. The solvent in a "spirit varnish" is not necessarily alcohol, but the varnish must dry by evaporation, and not by oxidation and resinification, as in the case with the fatty varnishes. The solvents used in the manufacture of lacquers are spirits of wine, oil of turpentine, tar oil, petroleum, ether, and benzole, and mixtures of these. Like any other varnish, a lacquer may be coloured, and any resin soluble in a volatile solvent may be employed in its preparation. Those most used are shellac, amber, copal, dammar, sandarach, colophony, asphaltum, indiarubber, and collodion.

Lactalbumin (*Chem.*) A constant constituent of all kinds of milk; but it is always present in small amount. It resembles in general serumalbumin, but differs from this in rotatory power, temperature of coagulation, and in solubility. Said to have been crystallised.

Lactams (*Chem.*) Compounds similar to the Lactones (*q.v.*), but having the ring closed by an Imino group (NH) instead of oxygen; *e.g.*

$CH_2CH_2CH_2CO$ is γ-butyrolactam.
NH

They are formed by heating the γ and δ amino acids, and on boiling with alkalis (*e.g.* NaOH) they are converted to salts of the amino acid from which they are derived (compare Lactones). Certain Lactams exhibit Tautomerism, *e.g.* Isatin—the lactam of isatinic acid.



Tautomeric Form.

The form $C_6H_4\langle {CO \atop N} \rangle C.OH$ is called the Lactim form.

Lacteals (*Zoology*). The lymphatic vessels found in connection with the intestine. They contain a milky fluid (CHYLE), and are concerned in the absorption of fats from the digested food.

Lactic Acid (*Chem.*), $CH_3.CHOH.COOH$. (α-oxypropionic acid). A syrupy liquid, soluble in water, alcohol, and ether. It readily loses water on heating, forming an anhydride,

$$CH_3CHOHCOO.C\left\langle \begin{matrix} CH_3 \\ H \\ COOH \end{matrix} \right.$$

The latter on distillation yields a second anhydride called lactide,

$$CH_3CH\left\langle \begin{matrix} COOC\left\langle {CH_3 \atop H} \right. \\ O\ O\ C \end{matrix} \right.$$

a crystalline solid. Heated with dilute sulphuric acid at 130° it yields aldehyde and formic acid. It behaves at the same time as a secondary alcohol and as an acid, *e.g.* oxidation with potassium permanganate changes it to a ketonic acid—pyruvic acid $CH_3COCOOH$; hydrobromic acid changes it to α-brompropionic acid; hydriodic acid to propionic acid; it forms two kinds of ethyl derivatives, *viz.*

$CH_3CHOC_2H_5COOH$	$CH_3CHOHCOOC_2H_5$
Alcohol Derivative.	Acid Derivative.

It occurs in sour milk, in the gastric juice in dyspepsia, in sauerkraut, etc. It can be prepared synthetically from propionic acid by heating the latter with bromine at 130°, and boiling the product for a long time with much water—

$$\underset{\text{Propionic Acid.}}{CH_3CH_2COOH} \rightarrow \underset{\alpha\text{-Brompropionic Acid.}}{CH_3CHBrCOOH} \rightarrow CH_3CHOH.COOH$$

also from aldehyde by allowing this compound to stand with prussic acid and hydrochloric acid—

$$CH_3.C\left\langle {O \atop H} \right. \qquad CH_3C\left\langle \begin{matrix} OH \\ CN \\ H \end{matrix} \right. \qquad CH_3C\left\langle \begin{matrix} OH \\ COOH \\ H \end{matrix} \right.$$

In quantity it is prepared by inverting cane sugar with tartaric acid, adding sour milk, putrid cheese, and zinc oxide. The process is one of fermentation, and the zinc oxide is added to remove the free lactic acid in the form of the zinc salt, because the ferment ceases action if the acid is allowed to accumulate. The zinc salt is recrystallised, decomposed by sulphuretted hydrogen, filtered, concentrated, and extracted with ether. Lactic acid contains a symmetric carbon

atom, $H - \underset{COOH}{\overset{CH_3}{C}} - OH$, and accordingly exists in three

forms. The synthetic acid, and that obtained by fermentation, are both optically inactive; this form can be resolved by making the strychnine salt and crystallising it, when the lævo-salt separates first. The dextro acid occurs in the juice of muscle and in meat extracts such as Liebig's; it is called SARCOLACTIC ACID.

Lactim (*Chem.*) *See* LACTAMS.

Lactometer. An instrument for determining the specific gravity of milk.

Lactones (*Chem.*) Anhydrides of oxy-acids which have the oxy-group separated from the acid group by two or three carbon atoms. The former are called γ-lactones and the latter δ-lactones; *e.g.* $\underset{\gamma}{CH_2OH}.\underset{\beta}{CH_2}.\underset{\alpha}{CH_2}.COOH$ is called γ-oxybutyric acid, and it readily loses water and forms butyrolactone $CH_2.CH_2.CH_2.CO$, which is a γ-lactone.
O

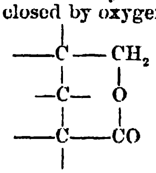
The lactones are liquids or solids, soluble in water, alcohol, ether, which on treatment with alkalis (*e.g.* NaOH) give the sodium salts of the corresponding acid. With halogen acids most of them yield the haloid acid, *e.g.* $CH_2CH_2CH_2CO$ (O) + HBr = $CH_2BrCH_2CH_2COOH$. The lactones are formed from the halogen acids by distillation or boiling with water; from the corresponding ketonic acids by

reduction; from dibasic acids by reduction of the chloride or anhydride. As lactones are only formed by γ- and δ-oxy-acids, it is clear that in the case of a substance of unknown constitution which either behaves like a lactone, or can be converted into a lactone, something can be inferred as to its constitution Thus camphoric acid forms an anhydride which yields a lactone on reduction:

$$C_8H_{14}\left\langle{CO \atop CO}\right\rangle O \rightarrow C_8H_{14}\left\langle{CO \atop CH_2}\right\rangle O$$

Camphoric Acid Anhydride. Lactone (Campholide).

So that in campholide we may infer a ring of four or five carbon atoms closed by oxygen, *e.g.*:



Lactose *or* **Milk Sugar** (*Chem.*), $C_{12}H_{22}O_{11}$. Forms white rhombic crystals containing one molecule water. Soluble in water; insoluble in alcohol. Its solution is dextro-rotatory. Lactose reduces Fehling's solution, also ammoniacal silver; on gentle oxidation it gives a monocarboxylic acid—lactobionic acid; oxidised by nitric acid, it gives a dicarboxylic acid—mucic acid; it yields a characteristic osazone (*see* OSAZONES); boiled with dilute sulphuric acid, it gives dextrose and galactose; it forms an octoacetate. These facts show that it is a hexahydric alcohol and also an aldehyde. It is much less sweet than cane sugar. Lactose occurs in the milk of mammals: human milk contains about 5 per cent. and cow's milk 3·8 per cent. on an average. Lactose is prepared from milk by coagulating the proteid (addition of a little strong acid) and evaporating the whey to a syrup, when crude lactose will crystallise out on standing in a cold place; it is recrystallised. It can be obtained very pure by dissolving in water and precipitating it with absolute alcohol.

Lacunar (*Architect.*) A sunk compartment or panel in a ceiling, etc.

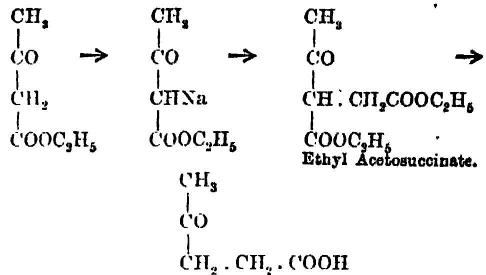
Ladder Rack (*Civil Eng.*) *See* MOUNTAIN RAILWAYS

Ladies (*Build.*) Roofing slates measuring 16 in. by 8 in.

Ladle (*Met.*) An iron vessel, generally lined with fireclay, used for conveying molten metal from the furnace to the moulds. Also an iron spoon used for holding molten lead or other metal, *e.g.* for fixing iron railings, etc.

Lævorotatory Compounds (*Chem.*) Compounds which rotate the plane of polarisation of a plane polarised ray of light to the left. *See* POLARISED LIGHT. If the substance is a solid, it is examined in solution in a suitable inactive solvent. *See* ASYMMETRIC CARBON ATOM.

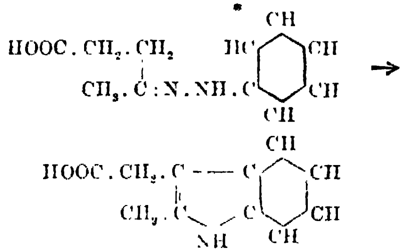
Lævulinic Acid (*Chem.*) β-acetopropionic acid, $\underset{\gamma}{CH_3CO}\,.\,\underset{\beta}{CH_2}\underset{\alpha}{CH_2}\,.\,COOH$. White solid, crystallising in scales; melts at 33°; decomposes on distillation at the ordinary pressure, but distils unchanged at 144° under 12 mm. pressure; very soluble in water, alcohol, and ether. It is obtained by boiling lævulose, or any sugar which yields lævulose on hydrolysis, with dilute sulphuric acid. Synthetically it is prepared from ethyl acetoacetate by acting on the sodium derivative with ethyl monochloracetate, and boiling the product with baryta water:



Ethyl Acetosuccinate.

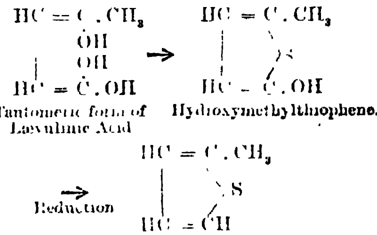
Lævulinic Acid.

As a γ-ketonic acid, lævulinic acid has the reactions of a ketone; thus on reduction it yields (*a*) with sodium amalgam γ-oxyvaleric acid (Na – salt); (*b*) with hydriodic acid it yields normal valeric acid. With hydrocyanic acid, hydroxylamine, and phenylhydrazine it behaves like other ketones; the phenylhydrazine derivative yields an indole derivative when heated with zinc chloride:



a-Methylindole-β-Acetic Acid.

P_2S_5 converts lævulinic acid into methylthiophene:



Tautomeric form of Lævulinic Acid

Hydroxymethylthiophene.

Reduction

Methylthiophene.

Lævulose, Fructose, *or* **Fruit Sugar** (*Chem.*), $CH_2OH\,.\,(CHOH)_3CO\,.\,CH_2OH$. A white crystalline solid (fine silky needles); melts at 95°; readily soluble in water; sweet taste, as sweet as cane sugar. It occurs along with dextrose in all ripe fruits, also in honey. It can be prepared by inverting cane sugar by a dilute acid (*e.g.* sulphuric acid), cooling to 0° and adding slaked lime; on shaking, the sparingly soluble lime-compound of lævulose separates out, leaving the more soluble dextrose compound in solution. After filtering and pressing, the lime compound is decomposed by suspending it in water and passing carbon dioxide through the liquid, when the calcium is separated as carbonate and lævulose remains in solution. On evaporation the lævulose remains as a syrup which crystallises with difficulty. Lævulose is also obtained pure from inulin by hydrolysing the latter with water. It can be obtained from dextrose by converting the latter

into the osazone, hydrolysing the latter with strong hydrochloric acid, and reducing the product:

$$\begin{array}{l} CH_2OH \\ | \\ (CHOH)_4 \\ | \\ CHO \end{array} \rightarrow \begin{array}{l} CH_2OH \\ | \\ (CHOH)_3 \\ | \\ C:N.NH.C_6H_5 \\ | \\ HC:N.NH.C_6H_5 \\ \text{Phenylglucosazone.} \end{array} \xrightarrow{HCl}$$

$$\begin{array}{l} CH_2OH \\ | \\ (CHOH)_3 \\ | \\ CO \\ | \\ CHO \\ \text{Glucosone.} \end{array} \xrightarrow{H} \begin{array}{l} CH_2OH \\ | \\ (CHOH)_3 \\ | \\ CO \\ | \\ CH_2OH \\ \text{Lævulose.} \end{array}$$

Hence lævulose can be synthesised. *See* DEXTROSE *and* OSAZONES. Lævulose is lævorotatory; its dextrorotatory modification is known and the racemic variety is the synthetic sugar α-acrose (*see* DEXTROSE). As an alcohol lævulose forms *esters* with acids or acid anhydrides, etc.; *e.g.* acetic anhydride and sodium acetate yield a penta-acetate, while benzoyl chloride and caustic soda yield a pentabenzoate; with alcohols and gaseous hydrochloric acid it yields ethers; with metallic oxides it yields compounds of the same type as the methoxides and ethoxides; *e.g.*, $C_6H_{12}O_6 3CaO = C_6H_6(CaOH)_3O_6$. As a ketone alcohol it yields on reduction the hexahydric alcohol mannitol, $CH_2OH(CHOH)_4CH_2OH$; on oxidation it yields trioxybutyric and glycollic acids, $CH_2OH.CHOH$ $CHOH.COOH$ and $CH_2OH.COOH$; with hydrogen bromide in presence of ether it yields α-brommethylfurfuraldehyde,

$$\begin{array}{l} CH = CH - CH_2Br \\ | \qquad\quad > O \\ CH = CH \cdot CHO \end{array}$$

With hydrocyanic acid, hydroxylamine, and phenylhydrazine it behaves as a ketone. The compound with hydrocyanic acid,

$$CH_2OH(CHOH)_3.C\begin{array}{l} \diagup OH \\ - CN \\ \diagdown CH_2OH \end{array}$$

on hydrolysis and reduction with hydriodic acid yields methylnormalbutyl acetic acid,

$$\begin{array}{c} C_4H_9 \\ | \\ CH_3 - C - H \\ | \\ COOH \end{array}$$

With excess of phenylhydrazine lævulose yields the same phenylglucosazone as dextrose. Lævulose reduces Fehling's solution and ammoniacal silver, and ferments with yeast like dextrose, but less readily.

Lag (*Weaving*). A strip of wood containing perforations into which pegs are inserted, and which determine the heald shafts to be lifted or lowered.

Lag and Lead (*Elect. Eng.*) If a varying electromotive force act in any circuit, the current produced will not in general be completely in step with the E.M.F. The maximum value of the current may be attained either before or after the maximum value of the E.M.F. Thus in the commonest case of a varying E.M.F., that of an alternating current, a difference of phase is produced between the current and the E.M.F. Let R be the resistance of the circuit, L its self-induction (*q.v.*), K its capacity, and $p = 2\pi n$ where n is the frequency. Then the angle of lag, ϕ, is determined by the equation

$$\tan \phi = \frac{pL - \frac{1}{pK}}{R}$$

If pL be greater than $\frac{1}{pK}$, the difference of phase is positive and the current lags behind the E.M.F., while if $\frac{1}{pK}$ be greater than pL, the difference of phase is negative, or there is a *Lead* in phase. If $pL = \frac{1}{pK}$, there is neither lag nor lead, and the impedance (*q.v.*) is equal to R, and the current in the circuit follows Ohm's Law.

Lagen (*Archæol.*) A liquid measure at one time in use in England, equal to about seven quarts.

Lagging (*Eng.*) (1) The process of covering a boiler, cylinder, etc., with some non-conducting material in order to prevent loss of heat. (2) The material itself which is used in this process. (3) Pieces of wood, etc., used in covering or building up large cylindrical objects, *e.g.* wooden drums, patterns, the centring on which arches are erected, etc.

Lagging Back (*Weaving*). The operation of reversing the pattern chain with the object of removing defective picks, etc.

Lagging of Tides (*Astron.*) At the time of neap tides the interval between the corresponding tides of successive days is greater than the mean, and the tide is said to lag.

Lagos Rubber. *See* CAOUTCHOUC *and* RUBBER.

Lagre (*Glass Manufac.*) A sheet of glass placed upon the flattening stone to prevent scratching in the manufacture of SHEET GLASS. *See* GLASS MANUFACTURE.

Laid Paper. Writing paper showing the wire marks, slightly ribbed. *Cf.* WOVE PAPER.

Lakes (*Dyeing, Dec., etc.*) The word lake has two meanings. For the dyer it means an insoluble colour compound formed on the fibre. It also means (*a*) a pigment consisting of an insoluble white solid or "carrier" dyed by some natural or artificial organic dye; (*b*) a coloured precipitate got by precipitating such dyes with metallic salts. We restrict ourselves to the consideration of lakes in the senses (*a*) and (*b*). The exact nature of the lakes we are concerned with is not accurately known. It no doubt varies, some of them probably being definite chemical compounds, others mixtures. The fact that acid dyes will combine with a metallic oxide as the latter is set free by an alkali (the application of which fact to lake making we shall soon see) would appear to favour the idea that at least the lakes of acid dyes partake of the nature of salts, and may therefore be definite compounds. Lake pigments for artists were formerly made by dyers from waste lac dye liquors (cochineal), and this is the origin of the name. A purple pigment was also prepared, says Pliny, from the scum of the baths in which Tyrian purple was dyed. An enormous number of lakes is now manufactured, and we can only here give some brief account of the principles of their formation, illustrated by a few examples. There are, then, two distinct methods of producing a lake. One is to mix a dye solution with one of a metallic salt, and then to precipitate the metal,

whereupon a precipitation is formed which entangles colouring matter and brings it down from solution in some way not well understood. If the metallic precipitate is white by itself, the colour of the lake may be due to the organic dye only; but the case is clearly different if the metallic compound has an independent colour of its own. The other method is to use a carrier in the solid form, and to throw down the organic dye upon it with a suitable precipitant. The chief CARRIERS used are china-clay, barytes, starch, gypsum, chalk, talc, red lead, and hydrate of alumina. This last method is the one chiefly employed with the basic dyes, and in its application the choice of a carrier is of very great importance, as any given dye has a carrier which will give greater brilliancy of hue and greater covering power than any other insoluble substance. The old madder lakes were excellent examples of the first method. Madder infusion was mixed with alum and precipitated with carbonate of soda. The lake was then filtered off and washed. Brazil wood lake is made in the same way, alum and tinsalt being added to the decoction, and then precipitated with soda. Most modern lakes are, however, made by the second process, or by a combination of the two, in which the carrier is thrown down separately, and then after washing is dyed with a solution of the dye. An ALIZARINE LAKE can be prepared by dissolving 100 lb. of alizarine (10 per cent. paste) in caustic soda, diluting largely, filtering if necessary, and adding a solution of 50 lb. of alum and 3 lb. of chloride of calcium in 80 gallons of water. A coloured lime alumina lake is thrown down. The same lake can be prepared, to give an instance of the combination above alluded to, by precipitating sulphate of alumina to which a little chloride of calcium has immediately before been added, with carbonate of soda. The precipitate of aluminic hydrate and carbonate of lime is then dyed by heating it with alizarine paste mixed with Turkey red oil and a little tannin. WALL PAPER LAKES are prepared from basic dyes by throwing them down upon a carrier of blanc fixe (precipitated barium sulphate), as no other carrier gives a lake with equal body. For BASIC DYES in general, however, the carrier most used is kaolin or porcelain clay. In some cases the carrier becomes dyed sufficiently well by being merely stirred up in the dye solution, but in most cases the action of a separate precipitant of the dye is essential. Alum, either alone or reinforced with carbonate of soda or tannin, is used for the purpose. Many lakes are made with tannin. A solution of alum, or of any suitable metallic salt, is taken, the carrier is stirred up in it with the dye solution, and the whole is then precipitated with a solution of tannin. For basic green dyes quercitron answers better than pure tannin, as it gives a lake of a better colour. The order of the operations may be varied. The carrier may be mixed first with the dye solution and the tannin, adding the metallic solution last. In either case chalk or carbonate of soda is used to complete the precipitation of the metal. These TANNIN LAKES have a bad reputation with oil painters, as they are said to be non-drying, but they answer very well for wall papers and water colour painting. As an instance of the use of a COLOURED CARRIER, the production of violet lakes by precipitating a red dye on to Prussian blue may be mentioned. AZO DYES are precipitated on a carrier with a salt of lead, calcium, or barium. Here the carrier may be used alone with the dye solution, or sodium aluminate or carbonate may be also added before the precipitation. The carrier is usually blanc fixe in paper staining and heavy spar for paint. EOSINE LAKES are much prized for their bright colours, and some of them (vermilionettes) are used as substitutes for vermilion. Lead salts are used as precipitants, and in some cases red lead is used as a carrier. One method of making the lake is to mix a paste of hydrate of alumina with a solution of eosine, and then to add a solution of lead nitrate. Various other eosine lakes of differing shades are made by precipitating the dye on a carrier of porcelain clay or starch, by alum; or by using a carrier compound of a mixture of red lead and gypsum; or by precipitating with salts of magnesium or zinc. Lakes must be well washed after making, till all that can dissolve has been removed. They are sold in powder, in paste, and also in blocks. There seems to be hardly any limit to the possible number of lakes, and their manufacture has become quite a fine art. They are procurable in hundreds of different colours and shades, produced by varying the dye, precipitant, and carrier, as well as the conditions of temperature, degree of concentration of the solution, etc., under which the dye is separated out in the solid form.

Lakes (*Geol.*) Local expanses of inland waters which are usually caused by some special conditions in one part of the channel of a stream, and are essentially quite temporary in character. They are due to various causes, amongst which are (1) the formation of a barrier of some kind, which forces the water back; (2) a local subsidence; (3) mechanical erosion of part of the river bed, such as is caused by glacial action; (4) to the filling, by water, of the craters of recently extinct volcanoes, etc.

Lalande's Cell (*Elect.*) *See* CELLS, PRIMARY.

Lamboys (*Arm.*) A kind of steel skirt reaching from the waist to the knee, and sometimes forming a part of body armour of the Tudor period.

Lambrequin *or* **Mantling** (*Her.*) A small mantle attached to the helmet. It is often arranged so as to form a background for the shield, and the whole forms the achievement. It appears jagged at the edges, as the actual mantle worn by knights in battle became much cut and torn.

Lamb's Tongue (*Joinery*). A flat ogee moulding used on sashes.

Lame (*Silk Manufac.*) *See* HEDDLE.

Lamina, *pl.* **Laminæ.** A thin layer or plate of metal, rock, tissue, bone, etc.

Laminated Work (*Carp. and Join.*) Curved ribs or other structures constructed of thin boards nailed together side by side.

Lamination (*Elect. Eng., etc.*) Building up with flat strips or plates. Cores of transformers (*q.v.*) and many other iron parts of electrical machinery are laminated in order to prevent the production of induced or FOUCAULT CURRENTS (*q.v*) in the metal. The planes of division are arranged to lie parallel to the lines of magnetic force which run through the iron, and at right angles to the direction in which any induced currents would tend to flow. By this means the path of the magnetic lines is unbroken, while that of the Foucault currents is interrupted and the currents are thereby reduced to a minimum.

—— (*Geol.*) An arrangement of the structural planes of a mineral or a rock in such a manner that they form thin parallel plates or laminæ. Thus nearly all coal presents typical examples of lamina-

tion, which is due to repeated alternations of thin sheets of cherry coal, cannel coal, and "mother of coal."

Lampblack. An impure form of carbon obtained by the incomplete combustion of substances such as turpentine, tar, fractions of petroleum not useful for other purposes, all of which are rich in carbon. The process may be imitated by turning up the flame of an ordinary paraffin oil lamp till it "smokes" strongly—that is, till the air supply is insufficient for the complete combustion of the oil. Lampblack consists of about 80 per cent. carbon, the other 20 per cent. being composed of unchanged substance and products of its decomposition by heat, in presence of the limited air supply. Soot is the most familiar form, but its strong brown tinge is fatal to its use as a pigment. The brown coloration is due to other products of partial combustion, and for lampblack manufacture combustibles are chosen which give less of these intermediate products. Oils are generally employed, and the soot obtained is freed from the brown substances by treatment with acids and caustic alkalies, till nothing but deep black pure carbon is left. Lampblack is the pigment of PRINTERS' INK and of CHINESE or INDIAN INK.

Lampoon. A virulent satire, in prose or poetry.

Lancashire Boiler (*Eng.*) *See* BOILERS.

Lance (*Arms*). A weapon consisting of a wooden shaft, shaped at the part where it was held and having a pointed metal head. Used almost universally and in all ages, but especially by knights in the Middle Ages. Also a weapon used in the whale fishery for despatching the whale.

Lance Rest (*Arm.*) In the period when armour was worn the lance rest consisted of a bracket fixed to the right side of the breastplate. The lance now has a strap attached, through which the arm is passed.

Lancet (*Architect.*) The name of one of the periods into which Sharpe divided English Gothic Architecture. His division is based on the form of the window, and Lancet-shaped or acute pointed windows are characteristic of the first part of the Early English period; the dates given by Sharpe being from 1190 to 1245 A.D. *See* CURVILINEAR *and* EARLY ENGLISH.

Lancet Arch (*Build.*) A pointed arch, having the radii of the segments longer than the span.

Lancewood. *See* WOODS.

Land and Sea Breezes (*Meteorol.*) Breezes blowing inland during the day and out to sea at night are commonly found at the sea coast in hot countries; the former is termed a SEA BREEZE, the latter a LAND BREEZE. They are commonly explained by the land being the hotter during the day; cool air rushes from the sea to compensate for the rarefaction thus caused; at night the land cools more quickly than the sea, and an air current in the reverse direction is thus caused. This explanation is, however, incomplete.

Lander (*Mining*). A man who empties a kibble (*q.v.*) as it comes up to the surface.

Landing (*Build.*) A horizontal platform at which a flight of stairs starts or finishes.

Landing Bar (*Lace Manufac.*) A bar peculiar to Lever's machine, to which the catch bars are attached. The two combined hold, support, and at the same time forward the carriages through their required movement.

Landolphia (*Botany*). Climbing plants belonging to the Dicotyledon order *Apocynaceæ*, and natives of Africa. They are the source of part of the rubber ("African rubber") of commerce.

Landscape (*Art.*) A picture representing some view of natural inland scenery.

Landslip (*Geol.*) An accidental displacement of a mass of rock by which it has been transferred from the surface at one part to that of a part near. Landslips are generally due to the undermining action of water in weakening the support which has previously kept an upper bed of rock in its place on a slope. A landslip may occur on a scale of almost any magnitude.

Langsam (*Music*). The German equivalent for Adagio (*q.v.*)

Langued (*Her.*) When the tongue of an animal or bird appears, it is "langued" and the tincture given when differing from that of the beast.

Langue de Bœuf (*Arms*). A weapon of the halberd or partisan character, carried by bodyguards. The broad blade was supposed to resemble the tongue of an ox, hence the name.

Lanoline (*Chem.*) A pale yellow semi-solid; separates into water and an oil on warming. The oil is purified wool fat, and consists of fatty acid esters of cholesterine (*q.v.*) and of an isomeric compound called isocholesterine. It is obtained from sheep's wool by washing the wool, then pressing it while hot, and treating the fat with alkalis to remove acids; alkali is removed by washing with a dilute mineral acid. Used as an ointment.

Lantern. *See* OPTICAL LANTERN.

Lantern Light (*Carp. and Join.*) A glazed light fixed on top of a roof, and having sashes at the sides and ends as well as the top.

Lantern Objective. An achromatic lens or combination of lenses, placed at the proper distance in front of the slide or other object to be exhibited on the screen; it is the part of the optical system which actually produces the image on the screen. The objective of an ordinary lantern is supported by a tube projecting from the front of the lantern, and is provided with a rack and pinion by means of which it may be moved backwards and forwards in order to focus the picture.

Lantern Pinion (*Clocks*). A pinion the leaves of which are cylindrical rods fitted between two circular plates. Advantageously used in the going trains of turret clocks. *See* PINION.

Lanthanum, La (*Chem.*) Atomic weight, 138. A rare metal belonging to the same group of elements as aluminium. Its compounds resemble those of aluminium, and they have similar formulæ; unlike aluminium, it burns in hydrogen at 210°, and on heating it in nitrogen it forms a nitride. It occurs in the rare earths Cerite, Gadolinite, Yttrocerite. Some chemists are of opinion that lanthanum is not a single element. Lanthanum has a complex and characteristic spectrum.

Laocoon (*Sculp.*) The famous group in the Vatican representing the Trojan priest Laocoon and his two sons enveloped by serpents. Regarded as a masterpiece of anatomical knowledge and realistic expression. The group was discovered in Rome about 1506, and is attributed to sculptors of the Rhodian school.

Lap (*Build.*) The distance that roof slates or tiles overlap the next course but one.

—— (*Eng.*) (1) The distance to which plates in a LAP JOINT (*q.v.*) lie over each other. (2) A piece of soft metal or wood, coated with fine emery or some other powder, used in finishing off polished surfaces of hard metal. (3) The form given to a slide valve in order to cut off the steam at a given point. *See* SLIDE VALVE.

—— (*Textile Manufac.*) The fleece of wool as it is delivered from the condenser, or it may be the narrow width of wool from the scribbler or intermediate, conveyed to a subsequent machine by what is known as the Scotch Feed.

Lap Dovetail (*Joinery*). The form of dovetail used in drawer fronts; the joint is invisible from the front, but can be seen on the board forming the side of the drawer.

Lapis Lazuli (*Min.*) Sodium and aluminium orthosilicate and sodium sulphide, $Na_4(NaS_3.Al)Al_2Si_3O_{12}$. Cubic, but rarely in crystals; more often massive. Blue. It is used as an ornamental stone, and also constitutes, when powdered, the pigment ultramarine. From Siberia, China, Hungary, etc. An artificial pigment, of nearly the same composition, has now replaced the mineral as a pigment.

Lapithæ (*Sculp.*) A mythical Thessalian race, represented on the metopes of the Parthenon (Battle of the Lapithæ and Centaurs). *See* ELGIN MARBLES.

Lap Joint (*Eng.*) A joint between two plates, one of which lies over the other for a short distance: the two are fixed together by rivets or bolts.

Laplace's Formula for the Velocity of Sound. *See* VELOCITY OF SOUND.

Laplace's Nebular Hypothesis (*Astron.*) An hypothesis which contends that the solar system has been formed from a vast glowing mass of gas extending beyond the orbit of Neptune, which has gradually contracted, leaving behind rings, which have eventually formed the planets.

Lapped Valve (*Eng.*) A slide valve with lap. *See* SLIDE VALVE.

Lappets (*Cotton Weaving*). A cheap method of ornamenting cloth by means of extra warp or whip yarn. An imitation of embroidery. The mechanism is attached to the loom; there are two forms, *viz.* the SCOTCH or CAM, and the LANCASHIRE or LATTICE.

Lapping (*Linen Manufac.*) When the cloth is bleached and finished, it is cut to lengths and folded up in various ways to suit the market for which it is intended. This is called lapping.

Lap Welding (*Eng.*) Joining two pieces of wrought iron or steel by laying the end of one over the other and welding them together; it is the most usual way of making a welded joint in the forge, and is also employed in making wrought iron tube which is welded at the seam.

Lap Winding (*Elect. Eng.*) One of the methods of winding the armature of a dynamo in which all the windings lie on the outside of the core. The elements or loops are so arranged as to overlap one another. *See* WINDING OF ARMATURES.

Larch (*Botany*). The bark of the larch, *Larix europæa* (order, *Coniferæ*), is used in tanning. *See* WOODS *and also* VENICE TURPENTINE.

Largamente (*Music*). In a broad, dignified manner.

Large (*Music*). *See* NOTES.

Larghetto (*Music*). A diminutive of Largo, somewhat broadly.

Largo (*Music*). Broad, dignified.

Larrying (*Build.*) Bedding the inside bricks of a thick wall in thin mortar.

Larva (*Biol.*) A term applied to the embryo of certain animals, *i.e.* the organism in certain of the early stages of its life, after it is freed from the ovum, but before it attains its adult form, *e.g.* a caterpillar is the LARVA of an insect.

Lash (*Silk Manufac.*) *See* COUPLING.

Latch. A contrivance for fastening a door, etc.; opened either by hand or by means of a key.

—— (*Arms*). Another name for the CROSSBOW (*q.v.*)

Latching (*Surveying*). *See* DIALLING.

Latent Heat (*Phys.*) The quantity of heat necessary to produce a change in the physical state of unit mass of a substance, without producing any change in temperature, *e.g.* 536 calories are necessary to turn 1 gram of boiling water into steam at 100°; therefore 536 is the latent heat for the physical change involved, *i.e.* the vaporisation of water.

Lateral Canal (*Civil Eng.*) A canal running between two points in a river's course, to provide a navigable channel where the part of the river itself is unsuitable, owing to shoals, rapids, etc.; or to cut off a long bend in the river.

Latex (*Botany*). The milky sap of laticiferous tissue occurring in certain natural orders. It is of economic importance, as it contains gum resins, tannins, gums, etc. *See also* RUBBER.

Lath. *See* LATHS.

Lathe (*Eng., etc.*) A lathe is a machine primarily intended for the production of circular objects. The material to be shaped is caused to revolve about a given axis, and a tool is held in a suitable position so as to operate continuously on the work as it revolves. The simplest form is the DEAD CENTRE LATHE, in which the material is supported between two CENTRES or pointed pieces of metal fixed in suitable supports. Rotatory motion is communicated directly to the material by means of a cord or belt. In the primitive POLE LATHE a cord is wrapped round the work; the lower end is attached to a treadle, which is pressed down by the foot, causing the work to revolve in the required direction. The upper end is attached to one end of a long pole, whose other end is fixed, so that the pole bends during the downstroke, and when the pressure of the foot is removed the pole straightens and raises the cord with the attached treadle. As the work necessarily revolves in the reverse direction during this upstroke, the tool is withdrawn until the next downstroke commences. This primitive appliance is still in use in certain industries. The watchmaker's TURN is a small dead centre lathe, accurately constructed of metal, and can be used for very exact and delicate work. In the ordinary form of lathe (fig. 1) the rotatory motion is imparted to the work by a revolving spindle or MANDREL which is supported by a coned bearing at B and an adjusting screw E in a fixed HEADSTOCK H, and driven by a belt passing over a CONED PULLEY C keyed on to

the mandrel. The connection between the work and the mandrel is obtained by some form of CHUCK screwed on at D, which may entirely support the

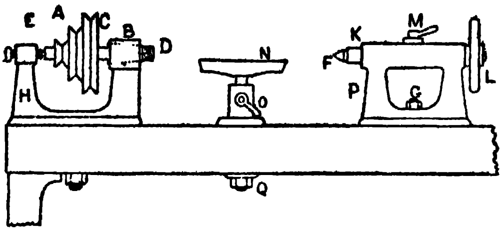


FIG. 1.

material in certain cases, or may support one end, and at the same time impart a rotatory motion to it. In this case the other end of the material is supported by a pointed CENTRE F, carried by the LOOSE HEADSTOCK or POPPET HEAD P. This slides along the bed, but can be fixed in any given position by means of a bolt G, which usually passes vertically downward through the slot between the two cheeks or members of the bed. The centre is then pressed against the work by means of the sliding cylinder K, which supports it; motion is communicated to K by means of a screw, on which is keyed the hand wheel L. When the centre F is screwed up so as to press sufficiently tightly against the work, the sliding cylinder K is clamped in position by means of a screw M. In hand turning the tool is steadied by resting in on a T REST N; this can be fixed at any point along the bed by means of a bolt Q, and can be raised and lowered in its socket, and clamped at any desired height by the set screw shown at O. The bed is usually an iron casting whose cross section is of the form shown in fig. 2. A, A are the two main members, or cheeks, united at the ends and stiffened at intermediate points by webs, one of which is shown at B. The upper surface is made as truly plane as possible, and provided with two V-shaped edges. The poppet and rests fit these V edges, and are kept in place by them. In FOOT LATHES the pulley is driven by a belt running over a heavy flywheel, which is carried on a crank shaft supported on bearings fixed to the standards (or legs), and rotated by means of a treadle; in POWER LATHES a countershaft (*q.v.*) is usually fixed immediately over the lathe, being driven by a belt from the main shafting of the shop. In some modern workshops, however, each lathe is driven by an electric motor, which may be connected directly to the headstock. Lathes intended for heavy metal work are usually provided with BACK GEAR; this is shown in a diagrammatic form in fig. 3. A, A is the mandrel; a pinion B is rigidly fixed to the coned pulley C, and the two can turn together loosely on the mandrel. A shaft D, D, parallel to the mandrel, carries a toothed wheel E and a second pinion F, both being keyed to the

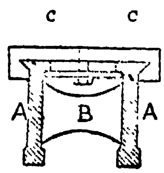


FIG. 2.

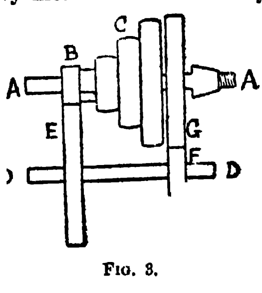


FIG. 3.

shaft, which can be moved parallel to itself so as to bring B and E into gear with each other or draw them apart. When B and E are in gear, the pinion F gears with a second toothed wheel G, which is keyed to the mandrel. Thus the latter revolves at a rate much less than that of the pulley when the gear is in action. When, however, a high speed is required, the shaft D is drawn back by mechanism provided for the purpose, and the toothed wheel G is locked to the pulley C, so that the mandrel then revolves at the same rate as the coned pulley C. Metal turning tools are rarely held in the hand, except in the very lightest work, but are supported in a SLIDE REST, which is attached to the bed of the lathe; by this means the tool is rigidly held, but can be given a linear motion, parallel to the axis of the bed, and a second linear motion at right angles. *See* SLIDE REST. In SCREW CUTTING LATHES the slide rest can be moved along the bed by means of a long square threaded screw parallel to the bed. This screw is caused to rotate by means of a train of wheels connected to the mandrel, so that the slide rest, and therefore the tool, move a given distance during each rotation of the work. This distance depends upon the relative velocities of the mandrel and leading screw, and therefore upon the number of teeth in the gear wheels by which the two are connected. A set of gear wheels, or CHANGE WHEELS, as they are termed, forms part of a screw cutting lathe, and by choosing suitable combinations of these, practically every thread required in ordinary work can be cut. In SELF ACTING LATHES motion can be communicated to the slide rest by means of a shaft, termed a BACK SHAFT, running along the back of the bed; this is so connected as to give either a motion parallel to the axis of the bed for SLIDING (*q.v.*), or a motion at right angles to this direction for SURFACING (*q.v.*) The size of a lathe is usually denoted by the radius of the largest piece of work which it will take in: thus a 5 in. lathe is one in which a cylinder of 5 in. radius (10 in. diameter) can be turned. The length of the bed bears no necessary ratio to this radius; but in many lathes the bed is ten to twelve times the height of the centres, *e.g.* a 5 in. lathe usually has a bed 4 ft. or 5 ft. long. In lathes for special purposes the length of the bed may be different. If a lathe be only intended for turning short objects of large diameter (*e.g.* wheels), the bed may be greatly reduced or be separated altogether from the headstock, and become a mere support for the slide rest, the poppet head being dispensed with altogether. Such a lathe is termed a BREAK LATHE. Very large break lathes are now constructed for turning flywheels, the armatures of large dynamos, and similar objects up to 40 ft. in diameter. A small lathe is often provided with a GAP in the bed (fig. 4). This allows a wheel, etc., of considerably larger diameter than the ordinary work to be accommodated in the lathe. When the gap is not required, it can be filled up by a GAP PIECE or BRIDGE, which is a casting similar in cross section to the bed itself. Lathes for ornamental turning and certain other classes of work are often provided with an OVERHEAD MOTION. This consists of a shaft fixed above the lathe and parallel to the bed, and from it milling cutters or drilling appliances held in the slide rest

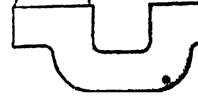


FIG. 4.

can be driven. It is distinct from the countershaft of a power lathe, being frequently driven from the flywheel of the lathe itself, and being further provided with some device for "taking up the slack" or tightening the belt by which the revolving tool is actuated, in order that the latter may be moved along the bed of the lathe while in rotation.

Lathe (*Silk Manufac.*) *See* BATTEN.

Lathe Bed (*Eng.*) The horizontal structure carrying the headstocks, slide rest, etc. It may be a single bar of metal (BAR LATHE) or two parallel bars of hard wood, or a somewhat complicated iron casting with a carefully planed upper surface whose edges are made exactly parallel, in order that the slide rest and back centre may be moved in an accurately straight path.

Lathe Standards (*Eng.*) The legs or frames which support the bed of the lathe.

Laths (*Carp., etc.*) Thin strips of wood, used for various purposes, but especially as a support for plaster; they are fixed so that a space intervenes between each lath and the one alongside. The plaster is forced into these spaces, thus forming a KEY, by means of which it is held in place.

Latitude and Longitude, Celestial (*Astron.*) The angular distance of a star from the ecliptic; it is measured along a great circle which is at right angles to the ecliptic. The angular distance of this great circle from the First Point of Aries is termed the celestial longitude of the star.

—— **Terrestrial.** The latitude of a point is its angular distance from the equator, measured along a meridian (*q.v.*) The longitude of a point on the earth is the angular distance between a meridian through the point and a fixed meridian termed the prime meridian. The meridian passing through Greenwich is the one almost universally used as the prime meridian.

Latitude, Libration in (*Astron.*) *See* LIBRATION.

Latten (*Met.*) A metal resembling brass in appearance, formerly used extensively for making monumental brasses. *See under* BRASSES, MONUMENTAL.

Lattice Girder (*Eng.*) A built up girder, in which the central portion or WEB (*q.v.*) is replaced by a series of diagonal bars forming a crossed or lattice work structure.

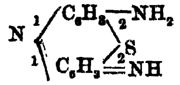
Laudanum (*Chem.*) A solution prepared from opium by treatment with equal parts of 90 per cent. alcohol and water, and then diluted so as to contain threequarters of one per cent. of the alkaloid morphine (*q.v.*)

Laughing Gas (*Chem.*) A common name for nitrous oxide. *See* NITROGEN OXIDES.

Laumontite (*Min.*) Hydrous silicate of aluminium and lime, $Al_2O_3 . 3SiO_2 + CaO . SiO_2 + 4H_2O$. Monosymmetric. It is one of the Zeolites (*q.v.*), and occurs in veins in volcanic rocks as a result of the decomposition of some of their constituent minerals by percolating water. Colour, white to yellow. On exposure it effloresces. Dumbartonshire, Fifeshire, Renfrew, Ireland, etc.

Launder (*Mining*). A trough in which water is led from place to place, for washing ore, working waterwheels, etc.

Lauth's Violet (*Chem.*) Thionine—



Black crystals with green colour when seen by reflected light; soluble in alcohol with violet colour. It is a base, and forms salts with acids, *e.g.* the hydrochloride—a green crystalline solid sparingly soluble in cold water, giving a violet solution. It is obtained by oxidising a solution of paraphenylene diamine with ferric chloride in presence of sulphuretted hydrogen; also by oxidising its leucobase (*see* LEUCO COMPOUNDS) with ferric chloride.

Lava (*Geol.*) The product arising from the cooling of what was originally a fluid mass which has risen, while at a high temperature, to the surface of a volcano and has flowed thence down its slopes. Some lavas cool very quickly, and thus do not flow far from the vent, while others remain fluid much longer, and may flow to distances of as much as fifty miles before coming quite to a standstill.

Lavatories in Workshops (*Hygiene*). Sec. 75, Factory and Workshop Act, 1901, requires that "in every factory or workshop where lead, arsenic, or any other poisonous substance is used, suitable washing conveniences must be provided for the use of the persons employed in any department where such substances are used."

Lavender. The lavender belongs to the natural order *Labiatæ* (*q.v.*) The most important plant is *Lavandula vera*, which is largely cultivated at Mitcham, Canterbury, Ampthill, and Hitchin. The flowers when distilled give true OIL OF LAVENDER, which is extensively used in perfumery and in medicine. It is remarkable that the best oil is procurable from English lavender only, though some maintain the superiority of the French oil; but a comparison between the market prices will at once show the relative estimation in which English and other oils are held. SPIKE LAVENDER is *Lavandula spica*, which yields an essential oil on distillation. The odour of the oil is far less esteemed than that of the oil from *L. vera*, and resembles that of a mixture of the latter oil with rosemary oil. It is used to some extent in soap and other perfumery, but not in medicine. The true lavender oil, which is much dearer, is sometimes adulterated with spike oil.

Law. A LAW in science is a statement of the results which follow from the operation of certain specific natural causes. A law may be deduced accurately from experiment or calculation, or may be inferred from observations of a sequence of events not completely understood.

Law Calf (*Bind.*) The calf skin used for binding law books is generally undyed, *i.e.* white. Law calf is therefore white calf.

Lawn. A light, plain texture linen fabric somewhat like cambric, but more open, and having a more gauzy appearance. It is used for dresses, handkerchiefs, etc.

Law of Constant Heat Summation (*Chem.*) An application of a general law, which holds for all kinds of energy, to the thermal changes occurring during chemical reactions. This law, stated by Hess in 1840, is as follows: Let A be the amount of energy in any units possessed by a system before it undergoes a given change, and B the amount of energy

in terms of the same units, possessed by the system after the change; then (A − B) is the same in whatever way the system passed from its initial to its final state. This law is applied in thermal chemistry to find the heat of formation of substances when it cannot be done directly from the elements themselves—that is to say, in the great majority of cases. Example: Formic acid contains the elements carbon, hydrogen, and oxygen; but it cannot be made by the direct union of the three. To find its heat of formation the procedure is as follows: The formula of the acid is CH_2O_2: so a weight of the acid equal to its formula weight (12 + 2 + 32 = 46 grs.) may be burned in oxygen to carbon dioxide and water and the heat given out during the combustion measured. The result of this process is that 44 grs. of carbon dioxide and 18 grs. of water are obtained, and when these have cooled to a certain temperature the heat given out is 65,900 calories. Now 12 grs. of carbon are burned to carbon dioxide, and the same temperature being reached, this process gives 96,960 calories. Finally 2 grs. of hydrogen are burned to water, and this gives 68,360 calories. The initial system is 12 grs. of carbon, 2 grs. of hydrogen, and 32 grs. of oxygen; the final system is 44 grs. of carbon dioxide and 18 grs. of water. In the first case the final system was reached in two stages, *viz.*: (1) The initial system was converted to formic acid by some process we need not consider and involving an unknown number of calories x. (2) The formic acid was burned to give the final system involving the production of 65,900 calories. In the second case the final system was reached by burning the carbon and hydrogen to give the same final system as before and in this case the number of calories evolved is (96,960 + 68,360). By the law the calories involved in each case is the same. Therefore $x + 65{,}900 = 96{,}960 + 68{,}360 \therefore x = 99{,}420$ calories.

Law of Constant or Definite Proportions (*Chem.*) *See* LAWS OF CHEMICAL COMBINATION.

Law of Multiple Proportion (*Chem.*) *See* LAWS OF CHEMICAL COMBINATION.

Law of Reciprocal Proportion (*Chem.*) *See* LAWS OF CHEMICAL COMBINATION.

Laws of Chemical Combination (*Chem.*) (1) LAW OF DEFINITE OR CONSTANT PROPORTIONS: This law states that in a given compound the elements are united in proportions which are fixed and invariable. The truth of this law has been assailed by more than one famous chemist—for example, by Berthollet (1799) and by Marignac (1860). On account of the doubts raised by Marignac as to the strict validity of the law, Stas undertook two researches—*viz.* (*a*) on the constancy of the composition of so-called stable compounds; and (*b*) on the invariability of the proportions by weight of the elements which go to form a chemical compound. In the first of these he showed that the ratio between ammonium chloride and silver is expressed by a constant whatever may be the method of formation of the ammonium chloride and of the silver chloride; in the second research he showed that in silver chlorate, bromate, and iodate the ratio of silver to oxygen was always constant. (2) LAW OF RECIPROCAL PROPORTIONS: If one substance, A, unite with each of the substances B, C, D, etc., then if B, C, D, etc., unite with each other, they will do so in the same proportions as they united with A, or in some simple multiple or submultiple of these proportions. This law was discovered in 1792. It follows at once from Dalton's Atomic Theory, so that its statement at the present time as a Law of Chemical Combination is mainly of historical interest. (3) LAW OF MULTIPLE PROPORTIONS: When one element unites with another in more than one proportion, these proportions stand in a simple ratio to each other. Dalton discovered this law about 1802, but it was formally announced by his friend Thomson in 1804. The compounds which led Dalton to formulate his important generalisation were few in number. He showed that nitric oxide combines with half its own volume of oxygen, and with double this volume, to form two other compounds; that a given weight of carbon combines with oxygen in two different proportions, one double the other; that carbon combines with hydrogen in two different proportions, one double the other. According to Roscoe and Harden, Dalton had conceived the Atomic Theory first, and deduced this law as a necessary consequence of it. (4) LAW OF GASEOUS COMBINATION (GAY LUSSAC'S LAW): When gases combine together they do so in volumes which stand in a simple ratio to each other and to that of the product of their combination. Example: Chlorine and hydrogen unite to form hydrogen chloride, and we have: vol. of chlorine: vol. of hydrogen: vol. of hydrogen chloride = 1 : 1 : 2. This law was published by Gay Lussac in 1808.

Lay (*Plastering*). *See* PRICKING UP.

—— (*Silk Manufac.*) *See* BATTEN.

—— (*Typog.*) The order in which type is arranged in the cases. The correct placing of the forme on the machine for printing.

Lay Cords (*Bind.*) Pieces of cord forming loops on the cross-bar of the sewing press. In sewing the sections of a book together, one end of each band is attached to a lay cord, which holds it in position. *See* BANDS, KEY (*Bind.*), *and* SEWING PRESS *under* BOOKBINDING.

Layers *or* **Lay Away Pits** (*Leather Manufac.*) The pits in which hides are laid flat in tan liquor with a layer of ground tanning material separating each hide. Sole leather is often laid away in this manner for six to ten months. *See also* LEATHER MANUFACTURE.

Lay Figure (*Art*). A jointed wooden model of the human figure. The joints being articulated, the limbs may be made to assume various positions. Used by artists for arranging draperies, posing, etc.

Laying Down Board (*Foundry*). *See* BOTTOM BOARD.

Laying Out (*Eng.*) The marking of materials, etc., for a piece of work to the full size. The term is applied specially to the marking of sheet metal for boiler making, coppersmiths' work, etc.

Laying Press (*Bind.*) *See* LYING PRESS.

Laying Trowel (*Plast.*) A tool resembling a FLOAT (*q.v.*), having a rectangular steel blade with a handle fixed to the back and parallel to the blade. Used for laying plaster on walls and ceilings.

Lay Light (*Build.*) A horizontal window placed in a ceiling to light a room below.

Lay Marks (*Print.*) The marks or stops used as guides for laying the sheet in printing.

Lay Panel (*Carp. and Join.*) A panel with the grain running horizontally.

Lay Shaft (*Eng.*) The shaft used in gas engines to transmit motion from the main shaft of the engine to the valve gear.

Lea (*Cotton Manufac.*) A seventh part of a hank, *i.e.* 120 yards, sometimes termed a WRAP.

—— (*Linen Manufac.*) The same as "cut." It consists of 120 threads 90 in. long, or 300 yards of yarn.

Leaching *or* **Leeching,** *also called* **Lecking** *and* **Letching** (*Leather Manufac.*) The process of extracting the tannin from barks or other tanning materials. The ground materials are put into large pits or vats called LEACHES, and covered with water. After standing the requisite time the liquor is run off. The process (leeching) is repeated until the tannin is all extracted.

Lead, Pb. (*Chem.*) Atomic weight, 206·9. A silvery white metal, when chemically pure, which quickly tarnishes in the air, owing to slight superficial oxidation. Melts at 327°; specific gravity, 11·3415, or when pressed, 11·347. It is very soft, so that it marks paper, and can be made into wire and piping by pressure. Heated in air it forms the monoxide, then on long-continued careful heating red lead. Quite pure water has no action on lead, but if the water contains dissolved oxygen the sparingly soluble basic lead hydroxide is produced and some hydrogen peroxide is formed: hence a very pure *natural* water cannot be passed through lead pipes if it is to be used for drinking purposes, the lead dissolved being sufficient to cause lead poisoning. This action of water on lead is facilitated by the presence of nitrates, especially ammonium nitrate; but the action is retarded and finally prevented by carbonates, sulphates, and phosphates, the pipe being coated by lead carbonate, etc., which are insoluble in water. Dilute hydrochloric acid only attacks lead in presence of air, and then slightly; but the boiling strong acid forms lead chloride and hydrogen. Hot and concentrated sulphuric acid dissolves lead owing to the formation of a soluble acid sulphate. Concentrated nitric acid does not dissolve lead, probably because of the formation of a minute film of nitrate on the metal, and the nitrate, being insoluble in nitric acid, stops further action; warm dilute nitric acid dissolves lead readily. Lead is precipitated from solutions of its salts, *e.g.* from the acetate, by zinc; in this case the metal is deposited in a treelike form, termed the LEAD TREE. Pure lead can be obtained by distilling ordinary lead in the vacuum produced by a good mercury pump in porcelain tubes, and the process can be watched by the Röntgen rays, which are transmitted by porcelain but not by lead vapour. Lead occurs naturally as sulphide (chief ore), carbonate, sulphate, chromate, and basic chloride; these compounds are called respectively GALENA, CERUSSITE, ANGLESITE, CROCOISITE, MATLOCKITE ($PbOPbCl_2$), and MENDIPITE ($2PbO . PbCl_2$). Also of interest are two naturally occurring compounds of lead chloride, one with lead phosphate, PYROMORPHITE, $PbCl_2 . 3Pb_3(PO_4)_2$; and another with lead arsenate, MIMETITE or MIMETESITE, $PbCl_2 . 3Pb_3(AsO_4)_2$, which are pseudo-isomorphous with Apatite (*q.v.*) Several methods are in use for the extraction of lead from its ores. The following is a brief outline of one of these: The ore is picked by hand, crushed, and washed to remove lighter earthy impurities: it is now spread evenly over the hearth of a reverberatory furnace, in which it is heated to a low temperature while a current of air passes over it. In this operation some lead is obtained and drawn off, but the chief result is oxidation of a part of the sulphide to oxide and sulphate, and escape of sulphur dioxide. The temperature of the furnace is now raised, and some quicklime added to the charge to give it a consistency more favourable to the separation of more lead. This operation is twice repeated, the lime in these stages decomposing any lead silicate which may have formed, and the lead being produced by the mutual action of the lead sulphide, oxide, and sulphate: $PbS + 2PbO = 3Pb + SO_2$

$PbS + PbSO_4 = 2Pb + 2SO_2$

The residue, called slag, still contains lead, and is treated for the recovery of its lead in small blast furnaces in which it is heated to a much higher temperature and with the addition of coke; this lead is not so pure as that from the reverberatory furnace, and has to be refined by melting it at as low a temperature as possible, so that only the lead melts and the impurities float on the top and are removed, while any impurities which dissolve in the lead are removed by oxidation. Galena usually contains silver, and this metal passes into the lead in the process of extraction of lead. Silver was formerly removed by PATTINSON'S PROCESS. In this process lead containing silver is melted and allowed to cool, with stirring, until solidification begins; the *solution* of silver in lead, when it begins to solidify, first separates lead containing little silver, while the lead rich in silver remains liquid. The poor lead is placed in one vessel, the rich lead in another, and the process is repeated on a fresh charge. The process is repeated on the poor lead and on the rich lead until products containing respectively half an ounce to the ton and 500 ounces to the ton are obtained; the former is then sold as lead, the latter treated for its silver by cupellation (*q.v.*) Lead is now desilverised by the PARKES' PROCESS, in which the argentiferous lead is melted and a proportion of zinc, depending on the amount of silver in the lead, is added to it. Silver is far more soluble in zinc than in lead; also when molten, zinc is nearly immiscible with lead, hence Parkes' process may be compared to extracting a substance from water by shaking it with a solvent which is immiscible with water and which dissolves the substance much better than water. When the molten mixture of the three metals has been well agitated by blowing dry steam through it, it is allowed to cool: the zinc floats on top with the silver dissolved in it, and is removed on solidification. The lead retains a little zinc, and has to be refined as described above. The silver is obtained free from zinc by distilling the argentiferous zinc when the latter passes over. Lead is used in making gas and water pipes, in roofing, in the construction of sulphuric acid chambers, in accumulators, in shot making, and it enters into the composition of some important alloys, such as type metal, pewter, solder, and fusible metal. RADIO-ACTIVE LEAD: Lead compounds obtained from pitchblende and other minerals containing uranium and thorium are strongly radio-active. According to Hofmann this activity is due to a primary active component, which is not uranium, thorium, radium, etc. Its activity can be diminished, *e.g.* by adding bismuth nitrate, evaporating with hydrochloric acid, allowing to stand fourteen days, extracting with hot water, filtering, and precipitating the filtrate with sulphuretted hydrogen. The sulphide so obtained shows feeble α-radiation and no β-radiation; but in three to four weeks it regains its original activity. The radio-active lead can be concentrated, and highly concentrated preparations show several peculiarities;

the sulphate becomes red on heating to 400°, the sulphide precipitated from dilute hydrochloric acid solution is grey brown, the chloride becomes rose coloured and the hydroxide yellow. Solutions of radio-active lead salts impart activity to other metals, as gold, silver, platinum. The feebly active lead sulphate from pitchblende (not concentrated radio-active lead sulphate) has its activity increased by exposure to a strong kathode radiation.—W. H. H.

Lead (*Elect. Eng.*) *See* LAG AND LEAD.

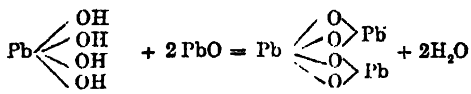
—— (*Min.*) This element is reputed to have occurred native at Alston Moor in Cumberland, at Dufton Mines in Westmorland, near Bristol, in Ireland, in Moravia, and near Lake Superior. In any case, as a mineral it is very rare. The principal ores are galena, cerussite, anglesite, and pyromorphite. There are many rarer ones.

Lead, Action of Water upon (*Hygiene*). The waters which act most rapidly on lead are: the purest and softest, as rain, distilled, and such moorland water as contains a free acid (humic, ulmic, or sulphuric); also those containing organic matter, nitrates, nitrites, chlorides, great excess of carbonic acid or of oxygen. Hard waters containing carbonates, particularly carbonate of lime, have the least effect upon lead. No water should be used for drinking that contains one-tenth of a grain of lead in the gallon; any trace indicates danger.

Lead Burning (*Plumb.*) The formation of a more or less homogeneous joint between two pieces of lead by fusing their edges together with a hot flame. A hydrogen flame, supplied with air (less commonly with oxygen) under pressure, is used. As no solder is used, the joint resembles a WELD (*q.v.*) It is used in ordinary building work and in chemical industries in which corrosive liquids or fumes would rapidly destroy a soldered joint, *e.g.* in the leaden casings of sulphuric acid chambers.

Lead Burning Machine (*Plumb.*) A vessel in the form of a cylinder encased with wood, for generating hydrogen gas used in lead burning (*q.v.*)

Lead Compounds (*Chem.*) Lead forms two series of compounds: in the one series of compounds the metal is divalent, and in the other it is tetravalent. To the divalent series belong all the common lead salts, the oxide from which these salts are derived being the monoxide PbO; to the tetravalent series belong a few unstable salts, the oxide from which these salts are derived being the dioxide PbO_2. *Oxides:* The SUBOXIDE Pb_2O is obtained by careful heating of lead oxalate out of air; it is a grey black powder, easily decomposed into metallic lead and lead monoxide. The MONOXIDE PbO is prepared in large quantities by lead heated in air. When the temperature is insufficient to melt the oxide, the latter is of a dull yellow colour; but when the temperature is high enough to melt the oxide, the latter assumes the crystalline form on cooling, and has a brighter and a redder colour—the former variety is called MASSICOT, and the latter LITHARGE. This oxide may also be obtained by heating the carbonate or nitrate. It is very sparingly soluble in water, has an alkaline reaction, and readily forms salts with acids; it is easily reduced to the metal by heating in hydrogen or carbon monoxide, or on heating in the inner blowpipe flame, or by heating it with carbon. It dissolves in a solution of sugar. This oxide is very important technically: it is used in glazing earthenware; in making drying oils, as it accelerates the absorption of oxygen, on which the "drying" depends; in making flint glass; and in making lead plaster. RED LEAD (triplumbic tetroxide), Pb_3O_4, is obtained by prolonged heating of the monoxide in air at a suitable temperature It is best regarded as lead orthoplumbate—



Orthoplumbic Acid.

It has a bright red colour, becomes black on heating, and decomposes into the monoxide and oxygen. Sulphuric and hydrochloric acids decompose it, yielding the sulphate and chloride and oxygen and chlorine respectively; nitric acid yields lead dioxide and lead nitrate, because lead dioxide is not decomposed by this acid. Red lead is used as a paint and in making flint glass. The DIOXIDE (peroxide, or puce-coloured oxide of lead) PbO_2 is obtained by the electrolysis of soluble lead salts or of lead sulphate suspended in dilute sulphuric acid—

$$PbSO_4 + SO_4'' = Pb(SO_4)_2$$
$$Pb(SO_4)_2 + 2H_2O = 2H_2SO_4 + PbO_2$$

It is also obtained by the action of nitric acid on red lead—

$$\left[\begin{array}{c} Pb_2PbO_4 + 4HNO_3 = H_4PbO_4 + 2Pb(NO_3)_2 \\ H_4PbO_4 = PbO_2 + 2H_2O \end{array}\right]$$

and by the action of oxidising agents on lead monoxide or its salts. Usually it is a dark brown powder, but a naturally occurring variety (Plattnerite) is crystalline, as also is the electrolytic product when slowly deposited. On heating, it gives the monoxide and oxygen. The ease with which it yields oxygen causes it to act as a powerful oxidising agent, *e.g.*

$$5PbO_2 + 2MnSO_4 + 6HNO_3 = 2HMnO_4 + 2PbSO_4 + 3Pb(NO_3)_2 + 2H_2O$$

With sulphur dioxide it combines energetically to form lead sulphate, and with nitrogen peroxide to form lead nitrate. Strong acids (except nitric) give tetravalent lead double salts with the dioxide, while aqueous acids give divalent lead salts, *e.g.*

$$PbO_2 + 6HCl = H_2PbCl_6 + 2H_2O$$
$$PbO_2 + 4HCl = PbCl_2 + Cl_2 + 2H_2O$$

The dioxide has also weak acid properties, forming plumbates with alkaline hydroxides, *e.g.*

$$K_2PbO_3 . 3H_2O$$

Divalent Lead Salts. LEAD CHLORIDE, $PbCl_2$, is a white crystalline solid sparingly soluble in cold water, much more soluble in hot water. It forms a number of basic salts, some of which are used as paints, *e.g.* $PbCl_2 3PbO$ is TURNER'S YELLOW Lead chloride is obtained by adding hydrochloric acid to hot dilute solutions of the nitrate or acetate, or by dissolving lead oxide in hot hydrochloric acid and allowing it to crystallise. LEAD SULPHATE, $PbSO_4$, is a white solid very sparingly soluble in water (1 : 22,800), and less soluble in dilute sulphuric acid (1 : 36,500); readily soluble in caustic soda or ammonium acetate. It is obtained by adding a solution of a sulphate to a solution of lead nitrate or acetate; it can

be crystallised from strong sulphuric acid. LEAD NITRATE, $Pb(NO_3)_2$, is white crystalline solid, readily soluble in water (50 parts in 100 at 12°), and decomposes on heating: $Pb(NO_3)_2 = PbO + 2NO_2 + O$. It is obtained by dissolving lead, lead oxide, or lead carbonate in dilute nitric acid; the salt is insoluble in strong nitric acid. Sometimes used as a weak oxidising agent, as it is slightly hydrolysed by water. LEAD SULPHIDE, PbS, is a black solid insoluble in water. Dilute nitric acid dissolves it on warming, forming the nitrate, and liberating sulphur; stronger acid oxidises it to sulphate. It combines with lead chloride to form a red chlorosulphide, $PbCl_2.3PbS$. *Compare* TURNER'S YELLOW. It may be obtained by heating sulphur and lead together, or by passing sulphuretted hydrogen into a solution of a lead salt. LEAD CARBONATE, $PbCO_3$, a white solid, insoluble in water, obtained by adding ammonium carbonate to a solution of lead acetate. The basic carbonate, $Pb(OH)_2.2PbCO_3$, commonly called WHITE LEAD, is a white solid having a finely granular structure, the grains, which are circular or oval, varying in diameter from ·0001 to ·00004 of an inch. White lead is made (1) by exposing lead moulded in the form of gratings or lattices, termed WICKETS, and supported in vessels containing dilute acetic acid, to the action of fermenting tannery bark; the decomposing bark evolves heat, and gives off carbon dioxide, so that the changes that occur are probably as follows: Lead acetate is formed, then the basic acetate, and finally the basic carbonate (Dutch or Stack method). (2) By acting upon lead oxide in presence of a solution of lead acetate (practically basic lead acetate) with carbon dioxide. White lead is very largely used as a base in making paints, and also as a paint itself. A mixture of white lead with barium sulphate is also used as a paint under various names, as VENICE or HAMBURG WHITE. LEAD CHROMATE, $PbCrO_4$, is a yellow solid obtained by adding a solution of potassium chromate or dichromate to a solution of lead acetate; it is crystalline when the solutions are slowly mixed (by diffusion); amorphous otherwise. It is insoluble in water, but soluble in nitric acid and in caustic soda. Is used as a paint under the name CHROME YELLOW. When treated with caustic soda in the cold, it yields a basic chromate, $PbO.PbCrO_4$, which has a red colour, and is used as a paint under the name CHROME RED. LEAD ACETATE, $Pb(C_2H_3O_2)_2$, also called SUGAR OF LEAD, from its sweet taste, is a white solid crystallising with three molecules of water; very soluble in water, less soluble in alcohol, poisonous. It is prepared by dissolving litharge, PbO, in the theoretical quantity of dilute acetic acid. It is used in medicine, and also largely as a reagent and in the preparation of other lead compounds. On heating its solution with one molecular proportion of litharge, it yields a soluble basic acetate, $PbO.Pb(C_2H_3O_2)_2$, which is used in medicine under the name of Goulard extract. LEAD PLASTER is lead oleate, $Pb(C_{18}H_{33}O_2)_2$, and is made by heating litharge with olive oil and water at 100°. Lead salts of organic acids are easily decomposed by sulphuretted hydrogen into lead sulphide and the free acid; on this account lead salts of organic acids are often prepared as a step in the preparation of the pure acids. For an example *see* FORMIC ACID. *Tetravalent Lead Salts:* LEAD TETRACHLORIDE (Plumbic Chloride), $PbCl_4$, is an unstable yellow liquid, which readily decomposes into the dichloride and chlorine; excess of water converts it into the dioxide

$$Pb\begin{cases}Cl\\Cl\\Cl\\Cl\end{cases} + 4H_2O = Pb\begin{cases}OH\\OH\\OH\\OH\end{cases} + 4HCl$$

$$Pb\begin{cases}OH\\OH\\OH\\OH\end{cases}, \quad Pb\Big\langle\!\!\Big\langle + 2H_2O$$

It is obtained by adding the dioxide to cold concentrated hydrochloric acid, and treating the solution with ammonium chloride, when the yellow ammonium lead chloride $(NH_4)_2PbCl_6$, separates out; and this salt, on treatment with concentrated sulphuric acid, yields the liquid tetrachloride. LEAD DISULPHATE (Plumbic Sulphate), $Pb(SO_4)_2$, is a white powder obtained by electrolysis of strong sulphuric acid in a glass vessel containing a sheet of lead to serve as anode, and a porous pot also, containing strong sulphuric acid and a lead worm to serve as kathode, and to carry a current of water for cooling purposes. The disulphate which is deposited at the anode is collected and exposed on porous plates in a desiccator over strong sulphuric acid. It is not quite pure. Sparingly soluble in concentrated sulphuric acid. Decomposed by water like the tetrachloride. LEAD TETRACETATE, $Pb(C_2H_3O_2)_4$, forms white monoclinic prisms melting at 175°, and soluble in glacial acetic acid and in chloroform containing a little glacial acetic acid. It is immediately decomposed by water into the dioxide and acetic acid; hydrogen chloride gives the tetrachloride and acetic acid. The TETRACETATE is prepared by gradually adding red lead to hot glacial acetic acid to saturation, filtering while hot, allowing to crystallise, then recrystallising from glacial acetic acid. LEAD TETRAMETHYL, $Pb(CH_3)_4$, is a colourless liquid having a slight smell like raspberries; boils at 110°. With iodine it forms lead trimethyl iodide, $Pb(CH_3)_3I$. Lead tetramethyl is obtained by the action of zinc methyl on lead chloride—

$$2\,PbCl_2 + 2Zn(CH_3)_2 = Pb(CH_3)_4 + 2ZnCl_2 + Pb$$

LEAD TRIMETHYL HYDROXIDE, $Pb(CH_3)_3OH$, is obtained as a low melting solid by distilling lead trimethyl iodide with caustic potash; it behaves like a strong alkali. Similar ethyl compounds are known.—W. H. H.

Lead, Desilverisation of (*Chem.*) *See* LEAD.

Leader. A leading article in a newspaper, being an expression of editorial opinion on some subject. Generally set in rather large type.

—— (*Mining*). (1) A small vein which seems to indicate the proximity of larger veins of a metal. (2) A stream which by its colour indicates the presence of minerals.

—— (*Typog.*) A line of dots or dashes cast on one em of a particular body, and intended to guide the eye, thus ....

Leaderette. An editorial paragraph in a newspaper, printed in the same type as a leader (*q.v.*)

Lead Glass *or* **Flint Glass.** *See* GLASS MANUFACTURE.

Leadhillite (*Min.*) A very rare basic sulphate and carbonate of lead. Found at Leadhills in Lanarkshire and in the Caldbeck Fell mines. It occurs in small monosymmetric crystals with a perfect basal cleavage; the lamellæ are flexible. It is of a pearly white colour.

Leading Axle (*Eng.*) The axle carrying the front wheels of a locomotive engine, etc.

Leading Edge (*Eng.*) That edge of the blade of a screw propeller which cuts the water first.

Leading Note (*Music*). The technical name for the seventh degree of the scale, so called from its tendency to lead upward to the tonic, below which it is only a semitone.

Leading Out (*Typog.*) Widening the spaces between lines by means of leads (*q.v.*)

Leading Screw (*Eng.*) A screw with an accurately cut square thread, which moves the slide rest on a SCREW CUTTING LATHE (*q.v.*) *See also* LATHE.

Leading Springs (*Eng.*) The front springs of a locomotive, etc., *i.e.* those immediately over the leading axle. These springs have to sustain a large amount of vibration and shock, and are therefore made of considerable strength, being usually built up of twelve to sixteen curved steel plates.

Lead Joint (*Eng.*) A socket joint in iron piping filled with molten lead, which is driven farther in when it has solidified, in order to fill up any irregularities.

Lead of a Slide Valve (*Eng.*) *See* SLIDE VALVE.

Lead of Brushes (*Elect. Eng.*) The brushes of a dynamo (*q.v.*) do not touch the commutator at the extremities of a diameter which is symmetrical with regard to the pole pieces, but have a forward displacement, termed a LEAD. *See* DYNAMO, figs. 2, 3, and 4. A displacement in the reverse direction is termed a BACKWARD LEAD; it is used in continuous current motors.

Leads (*Typog.*) Strips of lead or other metal of different thicknesses and length, used for effecting spaces between lines of type.

Lead Tack (*Plumb.*) *See* TACKS.

Lead Tree (*Chem.*) *See* LEAD.

Leaf Wood. The term often applied to the timber from the ordinary deciduous trees, *i.e.* those other than the pines and firs.

Leakage, Magnetic (*Elect. Eng.*) The passage of magnetic lines of force through a space or object in which they do not serve a useful purpose; *e.g.* in a dynamo or motor certain lines may pass from one pole piece to another through the air or through the frame or the baseplate, instead of passing through the armature.

Leaning Thread (*Eng.*) A screw thread of which the two sides (seen in cross section) are not inclined at the same angle; an example may often be found on a bolt which has to sustain a thrust in one direction only.

Lean-to Roof (*Build.*) A roof with one slope only, as in a building placed against a high wall. The tops of the rafters are nailed to a plate or bar of wood fixed to the wall.

Leaping Weir (*Civil Eng.*) A weir placed just in front of the intake of an aqueduct, and so constructed that when the stream is in flood, the powerful current will cause the water to shoot right over the opening of the aqueduct, while in normal conditions the water falls gently over the weir and enters the opening. Flood water, which is usually turbid and muddy, is thus prevented, to a very large extent, from entering the aqueduct.

Leap Years (*Astron.*) Years in which an extra day is added to the month of February to bring the calendar into conformity with the time of the earth's revolution round the sun.

Lear (*Glass Manufac.*) An annealing oven. *See* GLASS MANUFACTURE.

Lear Boards (*Carp.*) The boards nailed to the rafters in valleys (*q.v.*) and gutters to dress the lead upon.

Lease, Lese, *or* **Leese** (*Textile Manufac.*) In warping, the crossing of the warp threads alternately at the head end of the warp, and in groups of several threads at the footing end, in order to keep the threads straight when beaming and during weaving.

"Lease" *or* **"Cross" Rods** (*Silk Manufac.*) Two rods placed horizontally through the warp between the harness and the cane roll, the warp threads being alternately above the one rod and under the other, the cross or division thus formed keeping the threads in their proper order, enabling the enterer and twister to play them out in succession and facilitating the tracing and mending of those broken.

Leat (*Mining, etc.*) A watercourse, usually one excavated in the ground, as distinguished from a launder (*q.v.*)

Leather Manufacture. The manufacture of leather may be described as the conversion of raw hide or skin into an imputrescible substance, for certain purposes supple and soft; for other purposes firm and hard. This is effected by three main processes: (1) By impregnation of the hide or skin with a solution of "tannic acid" (tanned leather). (2) By treatment of the hide or skin with mineral salts (tawed or mineral leather). (3) By treatment with oils and fats (chamois or buff leather). In some cases combinations of any two or of all three processes are employed, producing DONGOLA or combination tanned leather. TANNING—SOLE LEATHER: The raw material for this purpose consists of the heavy hides of the ox and cow. These are obtained from practically all over the world, being preserved for transit by sun drying, "curing" with chemical preservatives, or by heavy salting. In process of manufacture they are first soaked in several changes of water to remove the cure, and to bring them back to a soft condition. They are then placed in pits containing a solution of milk of lime, to which is often added caustic soda or alkaline sulphides. The hides are frequently lifted from the pits, and the solutions strengthened. After from six to twelve days, according to thickness, the hides are swollen and the hair is loosened; they are then drawn on to a sloping beam, and the hair pushed off with a blunt knife. After the hair has been thoroughly removed, they are rinsed in water to remove excess of lime, again drawn on to the beam, flesh side upwards, and the fat and flesh left by the butcher is shaved off by means of a sharp fleshing knife. After again soaking, they are "rounded" by cutting off the belly and shoulder portions; the remaining portion, the "butt," is generally about 5 ft. square. Previous to entering the tan liquors, this raw butt is placed in water containing a weak acid to remove the lime, after which it is suspended in weak tan liquor and moved forward into successive pits containing tan liquor of greater strength. When evenly coloured, the butts are no longer suspended in the liquors, but are laid flat in them and "handled" frequently from pit to pit. When about half tanned the butts (goods) are put into still stronger liquors, and between each butt a layer of tanning material is sprinkled. This process is known as "laying away," the goods being laid in these liquors for periods varying from fourteen

days to three months. When thoroughly tanned, the whole period occupied varying from two to twelve months, according to thickness of the hide and the material used, the leather is removed from the pits, allowed to drip, and slowly dried until semi-dry, at which stage the leather is scoured and cleaned by hand or machine. This scouring removes dirt and all particles of tanning material, and flattens out the surface of the leather, making it smooth. A light coating of oil is applied; it is further dried and rolled under a heavy roller to give it firmness and solidity. After still further drying, a second rolling may be given when necessary, and the leather is then hung up in a heated shed until quite dry, when it is polished with a flannel cloth or brush. This completes the process. TANNING MATERIALS: Up to about fifty years ago practically the only tanning material used was oak bark, but gradually other tanning materials of greater strength have been introduced. Among the most important are valonia (the acorn cup of the Turkish oak), myrobalans (the fruit of an Indian tree), mimosa or wattle bark (from Australia and Natal), algarobilla and divi-divi (the fruit of two Indian trees), sumach (the leaf of a shrub growing chiefly in Sicily), and, more recently, mangrove bark. A still more important development in leather manufacture has been the introduction of strong tanning extracts of chestnut, oak, quebracho, and hemlock. Oak extract is chiefly manufactured in Hungary from oakwood. The wood is cut into fine shreds and soaked in hot water, and the liquor, after decolorisation, is concentrated in vacuum pans to a required density, and sold in casks. Chestnut extract is manufactured by similar means in France and Corsica, quebracho extract in the Argentine, and hemlock extract in Canada and the United States. The introduction of these materials has enabled the tanner to considerably shorten the process of leather manufacture. Previous to their introduction, when oak bark was the only tanning material obtainable, the manufacture of sole leather required from one to two years, as oak bark contains but little tannic acid or "tannin," this being the active principle of a tanning material. With the introduction of the newer materials, however, which contain from three to seven times as much tannin as oak bark, much stronger solutions or liquors can be used, with the result that the process may be completed in from three to nine months. LEACHING: Previous to making liquors from the tanning materials, these are ground or crushed in the mills, and then placed in large vats or pits and "leached" by maceration with water. The "leaches" are generally arranged side by side and material put into each, water being then run into one leach, and, after standing a few hours, being drawn off into the next leach by means of a pump. The liquor, on passing through each successive pit, gains in strength, until liquors are obtained containing as much as 10 per cent. of tannic acid. Into these liquors, strengthened with extract, are placed leathers of which the tanning is almost finished, and, as the strength is absorbed by the leather passing through, the liquors gradually work down through the tanyard until, on reaching the suspenders or early stage of tanning, the strength of a liquor is exhausted, and it is discarded as useless. SOLE LEATHER, as the term implies, is used for the soles of boots, shoes, and slippers. The thicker portion, cut from the butt or back, is used for heavy boots; that cut from the shoulder is somewhat thinner, and is used for light summer shoes and boots; and that cut from the belly is used for slippers and sandals. Hide shoulders and bellies undergo a like process of tanning to that described; but being thinner than butts, the tanning is completed more quickly. UPPER AND DRESSING LEATHERS: The hides and skins used for these leathers are the lighter and thinner ones. These undergo practically the same preparatory process of soaking, liming, unhairing, and fleshing as the heavy hides. But a softer and more supple leather is required, and this is obtained by tanning the goods in weak liquors, handling them frequently, and using tanning materials which are in their nature soft and not strongly astringent. When the process of tanning, similar to that already described, is completed, the leather, after dripping, is partially dried, lightly oiled, and, without scouring, cleansing, or rolling, is dried out. It is then ready for the process of "CURRYING AND DRESSING." This process may be generally described as impregnating the leather with oils and greases, and usually is as follows: The leather from the tanner is first softened by steeping in warm water; it is then worked over on both sides with brushes and stone knives to remove soluble tannins, dirt, and particles of tanning material, and afterwards bleached by steeping in warm liquors containing sumach or other suitable bleaching agent. After dripping, the leather is hung up to bring it into a suitable condition for stretching, which is done by laying it on a slate or stone table, and drawing it out from centre to edges by means of a brass or stone knife. The leather is now oiled on the upper or grain surface, and a coating of oil and tallow (dubbin) is brushed well in on the under or flesh side; it is then hung in a cool shed, when the moisture in the leather gradually dries out, its place being taken by the oil and tallow. This process may be repeated according to the amount of grease which it is desirable to incorporate into the leather, this depending upon the purpose for which the leather is to be used. If for BELTING, the leather is heavily stuffed with grease; for light STRAPS and HARNESS, less is applied; if it is for the UPPERS OF BOOTS and SHOES, only a light coating is necessary. The leather, having received the requisite stuffing, is slightly oiled, hung in a room for three or four days, and then laid in pile for the grease in it to set. Excess of grease is now removed from the surface by means of a blunt "slicking" or smoothing tool, and the leather is again stretched and polished; it is then ready for cutting into belting or straps. When the leather is required to be finished black for harness or for bootwork, it is blackened either by means of a solution of logwood and iron or by brushing with an aniline dye. Some leathers are finished flesh side outwards, in which case they are "waxed" with successive coatings of a mixture of lampblack and oil, the leather being dried between each coat, and finally polished by rubbing over with a rounded glass tool. FANCY LEATHERS: These leathers are manufactured from the skins of sheep, goats, calves, and seals. The skins arrive in this country in a similar condition to the hides of oxen and cows, already referred to. CALF LEATHER: The skins, after the preliminary process of soaking, liming, unhairing, and fleshing, are "puered" by steeping in a fermenting solution of excrement, and afterwards cleansed by drenching in a solution of fermenting bran. This dissolves out some of the interfibular substance and softens the skin. The tanning is carried out in a series of vats or pits, commencing with weak liquors and finishing with strong, the skins being handled frequently from one pit to another. The liquors are made chiefly

from oak bark. The leather when tanned is scoured and cleansed similarly to sole leather, but is usually shaved on the flesh side to make the whole skin of one thickness. Previous to drying it is oiled, and when dry it is sponged over with a solution of soap and mucilage; it is then redried and polished by brushing. If for shoework, the leather, after tanning and scouring, is dyed the requisite shade by immersion in a solution of aniline dye-stuff, rinsed to remove excess of dye, lightly dressed with oil and tallow, dried (excess of grease being removed as with curried leather), and polished by brushing; it is then ready for the shoe factory. MOROCCOS: The preliminary preparation of goat skins for tanning is in general the same as that of calf. This being completed, the goods are tanned in solutions of sumach; this tanning material imparts to the leather a light cream colour. Sumach being a rapidly penetrating material, the tannage requires from two to six days only. When tanned, the skins are "struck out" to remove excess of tan liquor, nailed on frames, and dried; when dry, the skins are soaked back, scoured, shaved to even thickness, and dyed in paddles or trays with a solution of aniline dye. When the requisite shade has been obtained, the skins are struck out to remove excess of dye, dried, damped slightly, and grained by hand to bring up the natural grain of the skin. A seasoning solution, consisting of blood, milk, or a suitable mucilage, is then rubbed on the surface, and the skins are glazed by machine, and sometimes re-grained and re-glazed: they are afterwards sorted into sizes in the warehouse. This leather is used for upholstery, bookbinding, pocket books, and other fancy work. SHEEP: The wool is the most valuable part of a sheep's clothing, being usually worth from four to six times as much as the skin. To remove the wool the flesh sides of the skins are painted with a strong paste of lime or sodium sulphide, and the skins then laid flesh to flesh; in about twenty-four hours the fleece can be removed by hand. After the wool is removed the pelts are treated similarly to goat and calf, tanned in bark or sumach liquors, dyed and finished in a similar manner to moroccos to make ROANS or BASILS, which are used for the cheaper class of slipper work, upholstery, and linings for boots. Many sheep skins are split, after liming, by passing the skin between two rollers which press it against a revolving knife. This splits the skin evenly, producing a thin grain split and a heavier flesh split. The grain split is tanned out in sumach, and is known as a SKIVER. After dyeing and finishing it is used for bookbinding and other fancy work, the flesh split being used for manufacturing CHAMOIS LEATHER. SEAL SKIN: These skins being full of grease or oil are, after soaking, blubbered. This consists of rotating the skins in tepid water in a large revolving drum to liquefy the fat, and working the skins over several times on a sloping beam with a blunt knife. By this means the grease is pressed out of the skin, after which it is limed and tanned in a similar manner to morocco and calf. Seal leather is used for portmanteaux, dressing cases, purses, and other fancy work. OIL AND BUFF LEATHERS: This heading includes chamois leather, buck-skin, suède glove leather, and leather for military accoutrements. Chamois leather is made from the flesh split of the sheep skin (*see under* SHEEP *above*); suède glove leather from the flesh split of goat, lamb, and deer skin; buff leather from heavy hides from which the grain surface has been removed by the buffing knife. For oil dressing the skins must be heavily charged with lime. After sprinkling with cod oil, they are placed in machines known as stocking mills, in which they are constantly beaten and turned, and as the oil is absorbed fresh oil is sprinkled on the skin. During the process the skins heat, owing to the decomposition of the oil, and care must be taken that they do not overheat and burn. After the requisite amount of oil has been beaten into the skins they are laid in piles to heat and for the oil to oxidise; when they have finished heating, the excess of oil is pressed out, the leather is then washed in an alkaline solution to remove all trace of oily matter, washed in water, bleached until the colour changes from brown to light yellow, softened by staking, and trimmed; the surface is then smoothed by pressing with a revolving emery wheel, which completes the process. TAWED LEATHERS: The term is applied to leather dressed for gloves; the skins used consist of lamb, kid, and deer. The preliminary processes of soaking, liming, puering, and drenching having been carried out, the skins are then placed in large revolving drums and rotated together with a tawing paste made of alum, salt, flour, and yolk of egg mixed into a thin paste. This paste penetrates the skin, and on completion the skins have been transformed into a white, tough leather. They are then dried and allowed to lie in stock for some weeks, to age. This ageing process makes the skins softer and tougher. They are then slightly damped with clean water, and are stretched over a staking knife. This staking process is repeated until the skins are sufficiently soft, after which they may receive a second drumming in a tawing paste in order to still more toughen the leather, the drying and staking being again repeated. They are fluffed on a fine emery wheel on the flesh side until of even thickness throughout; they are then dyed on the grain surface by brushing the skins over with a solution of any suitable dye-stuff, the alum acting as a mordant and fixing the dye. When dry they are sponged over with a mixture of white of egg, milk, and water, and ironed with a fairly hot iron to glaze. This makes the skin ready for the glover. CHROME LEATHER: The practical manufacture of chrome tanned leather dates from 1881, but mineral salts, chiefly those of iron and aluminium, had been used for a considerable time in the manufacture of leather. Modern chrome leather, both light leather for the uppers of boots and heavy leather for harness and belting work, is made by impregnating the skin (after the preliminary liming, unhairing, and fleshing have been completed) with a solution of chrome salt. The skins are generally placed in a pit or drum containing a solution of bichromate of potash, to which is added sufficient hydrochloric acid to set free the chromic acid. The chromic acid is at once absorbed by the skin, giving it a deep yellow colour; the skins are then removed from this solution and are placed in a second solution containing sulphurous acid or a sulphurous acid salt. This second bath reduces the chromic acid to chromic oxide and other complicated chrome salts. The leather, on emerging from this bath, is of a greeny white shade. After washing free from acid, the skins are shaved to even substance and placed in a revolving drum and drummed in a weak emulsion of soap and oil. After this fat-liquoring, the leather may be dyed with any aniline dyes, and after striking out, slowly dried. Before the leather is quite dry it is stretched and softened by staking, after which it is glazed, dried, and finished. Heavy hides for belting and harness work are usually tanned by a one-bath process. This consists of a solution of a basic chrome salt; the hides, like in ordinary tanning,

commence in a weak liquor and gradually, day by day, move into stronger liquors. By this process the heaviest hides may be tanned in from six to eight days. The process is frequently accelerated by tanning in a revolving drum, or by any suitable means of keeping the hides or liquor in constant movement. Chrome leather has made enormous strides since its introduction, and practically 50 per cent. of the uppers of boots are now being made of chrome leather. It has completely replaced the French calf and calf kid.—J. G. P.

Leathers (*Eng.*) CUP LEATHERS, etc. (*q.v.*), used in the packing of hydraulic presses. *See* HYDRAULIC PRESS.

Lebes (*Archæol.*) A large vessel, generally of metal, used by the Greeks and Romans for culinary and other purposes, *e.g.* for catching the water which was poured over the hands and feet after meals.

Lebhaft (*Music*). The German equivalent for VIVACE (*q.v.*)

Leblanc Process (*Chem.*) *See* ALKALI.

Lecithins (*Chem.*) Compounds of glycerine with fatty acids, phosphoric acid, and choline, *e.g.*

$$\begin{array}{l} CH_2OOC.C_{17}H_{35} \\ | \\ CHOOC.C_{15}H_{31} \\ | \\ CH_2O.PO.\left\langle \begin{array}{l} OH \\ OCH_2CH_2.N(CH_3)_3OH \end{array}\right. \end{array}$$

is a lecithin containing stearic and palmitic acids. They are wavy crystaliine solids, soluble in ether or ether chloroform. They are hydrolysed by dilute sulphuric acid or by baryta water to choline, fatty acid, and glycerine phosphoric acid. They form double salts with platinic chloride and cadmium chloride, and the latter has been shown to be dextrorotatory. The lecithins occur in brain and nerve tissue, in the blood, very largely in yolk of egg, and in growing vegetable cells. The lecithin from yolk of egg can be obtained by extraction with ether alcohol, distillation of extract, treatment of residue with alcohol, filtration, addition of alcoholic H_2PtCl_6, when the platinum double salt is obtained as a precipitate. The double salt is treated with sulphuretted hydrogen to remove platinum, filtered, and evaporated. Lecithin from yolk of egg is now used in medicine: it increases the number of red and white corpuscles, and is used in tuberculosis.

Leclanché Cell (*Elect.*) *See* CELLS, PRIMARY.

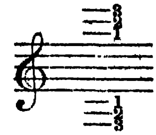
Lectern. A reading desk, especially that from which the lessons are read in a church.

Lecythus (*Pot.*) An ancient Greek vase with a narrow or constricted neck.

Ledged and Braced Door. The same as a LEDGED DOOR, with the addition of braces or pieces of wood running diagonally across between the opposite ends of two successive ledges.

Ledged Door (*Carp and Join.*) A door constructed of parallel boards or battens, placed vertically, and held together by horizontal rails or LEDGES, to which they are nailed.

Ledger Lines (*Music*). Short lines drawn above and below the stave for those notes which exceed the compass of the stave. Ledger lines are always counted outwards from the stave, *e.g.*



The first ledger line below the treble stave is the same note, C, as the first ledger line above the bass stave.

Ledgers (*Build.*) The horizontal poles of a scaffold on which the PUTLOGS (*q.v.*) rest.

Leeching (*Leather Manufac.*) *See* LEACHING.

Left Hand Thread (*Eng.*) A screw thread which runs round the screw in the opposite direction to the usual one; if the screw be viewed in vertical elevation, the thread appears to run upward as it is followed from right to left.

Legatissimo (*Music*). Very smoothly: as connected as possible.

Legato (*Music*). Smoothly, connected; abbreviation *leg.*, shown in music by a curved line over or under the notes:  or 

Legend (*Coins*). The letters or words appearing on a coin or medal.

Legend Line (*Typog.*) The line or lines placed under an illustration in a book or periodical to signify to the reader the nature of the illustration.

Leggiero (*Music*). Lightly; abbreviation, *legg.*

Legume (*Botany*). A dehiscent fruit setting free its seeds by the separation of two valves (*e.g.* Pea, Bean). The characteristic fruit of the order *Leguminosæ.*

Legumin *or* **Vegetable Casein.** A proteid very much resembling casein in milk. It is present chiefly in the seeds of beans and peas, and exists largely in combination with sulphur and phosphorus.

Leguminosæ. One of the most important and widespread of Dicotyledon orders. The peas, beans, clover, vetches, lentils, ground nuts, and many others form valuable food and fodder plants, while tropical forms yield timber, fibres, dyes, gums, resins, and oils.

Leicester Reds. *See* BRICKS.

Leish (*Silk Manufac.*) *See* COUPLING.

Leit Motif (*Music*). A musical theme to illustrate certain characters or ideas in a story. It recurs on each occasion these characters or ideas are brought forward. Especial use was made of the Leit motif by Wagner in his operas.

Lemon. *See* CITRUS.

Lemon Chrome (*Dec.*) A pale yellow pigment consisting of lead chromate, mixed with lead sulphate.

Lemon Grass Oil. An oil used in medicine and in perfumery; is distilled from the entire grass, *Andropogon citratus* (order, *Gramineæ*).

Lemon Juice (*Hygiene*). Valuable on account of its anti-scorbutic power; its use has practically eradicated scurvy from our navy and mercantile marine. The Merchant Shipping Act, 1867, requires that after ten days at sea each person shall receive an ounce of lemon or lime juice daily. Both lemon and lime juice contain citric acid (the principal constituent), some malic acid, proteid, and sugar.

Lenard Rays (*Elect.*) *See* RADIATION.

Leno (*Cotton Manufac.*) A combination weave for light fabrics (*e.g.* veils, curtains), consisting of a plain and figure weave and some form of gauze structure.

Leno Brocade (*Cotton Manufac.*) A brocade figure on a gauze ground.

Lens (*Light*). A single lens is a portion of a refracting medium, bounded by two co-axial spherical surfaces of equal or different radii. One of these surfaces may be plane, *i.e.* its radius is infinite. *See* CONCAVE, CONVEX, MENISCUS LENS, *etc.* The term LENS is also applied to a combination of lenses suitably mounted for purposes of photography, etc. As the rays most active in forming the photographic image are situate at the violet end of the spectrum, while those which affect the eye most strongly correspond to the yellow and yellowish green, it is necessary, in order to obtain a properly focussed image, that the lens be corrected for chromatic aberration, the violet and yellow rays being brought to a focus at the same point.

——, **Achromatic.** A combination of two (or more) single lenses, usually in contact, which produces deviation without dispersion (*q.v.*) It is more correctly termed an ACHROMATIC COMBINATION, and in the commonest cases (*e.g.* the object glass of a telescope or a so-called single photographic lens) consists of a convergent or convex lens of crown glass, cemented by means of Canada Balsam to a divergent or concave lens of flint glass.

Lenticular (*Min.*, *Mining*, *etc.*) Lens-shaped; applied to flat masses of ore, etc.; thinning out at the edges.

Lentil (*Botany*). *Lens esculenta* (order, *Leguminosæ*). A food plant from Western Asia, cultivated from ancient times for the sake of its nutritious seeds.

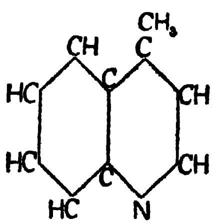
Lento (*Music*). Slow. The movement is slower than that indicated by ADAGIO.

Lenz's Law (*Elect.*) When currents are induced in any conductor by the motion of the conductor or a neighbouring magnet, or by another conductor in which a current is flowing, the direction of the induced current is such as to tend to stop the motion by which it is produced.

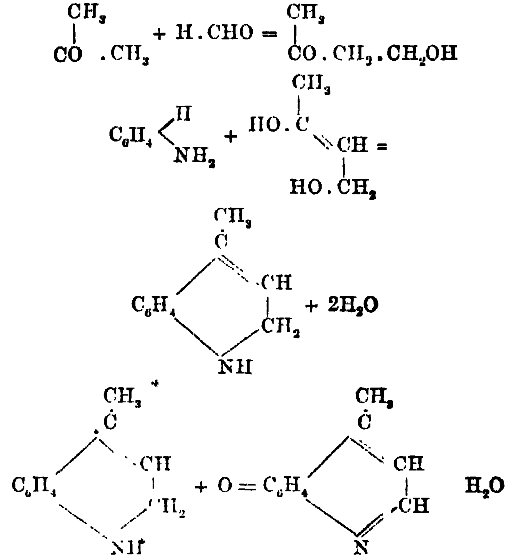
Leonids (*Astron.*) The swarm of meteorites which pursue their path round the sun in a period of about thirty-three years, but which every year, about November 15, meets the earth in her orbit, and gives us the phenomenon of a shooting star display. The main part of this swarm meets the earth every thirty-three years. The main showers occurred in 1833, 1866-7, and a not very brilliant shower in 1901.

Leopard, Lupard, *or* **Lybbardes** (*Her.*) Anciently "a lion passant guardant" was blazoned "leopard." The lions on the shield of England are thus blazoned, and are not, as some have supposed, leopards. When a leopard's head appears without any part of the neck, it is blazoned a "leopard's face."

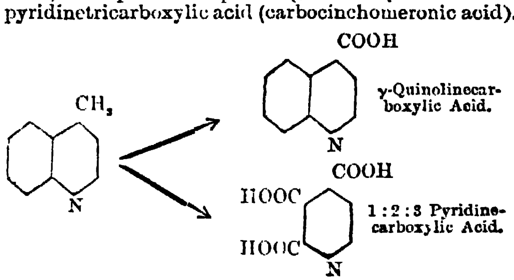
Lepidine (*Chem.*) (γ-Methylquinoline)



A colourless liquid; boils at 257°; smells like quinoline; soluble in alcohol and benzene. It occurs in coal tar; has been synthesised by condensing acetone with formaldehyde (in the form of methylal) by hydrogen chloride, adding aniline, and heating with concentrated sulphuric acid.



It is formed (amongst other products) by distilling cinchonine (*q.v.*) with caustic potash. On oxidation with chromic acid it yields γ-quinolinecarboxylic acid; with potassium permanganate it yields 1:2:3 pyridinetricarboxylic acid (carbocinchomeronic acid).



Lepidolite (*Min.*) A basic fluosilicate of potassium, lithium, and aluminium. Monosymmetric. It is one of the MICA group (*q.v.*) From Cornwall, Kinrossshire, Ireland, Moravia, Saxony, etc.

Lese (*Textile Manufac.*) *See* LEASE.

Letching (*Leather Manufac.*) *See* LEACHING.

Letterpress. Printing impressed by type, as distinguished from printing done from plates or lithographs.

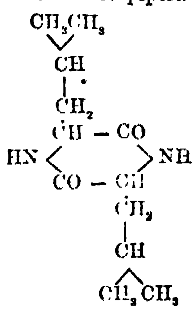
Letting Down (*Eng.*) Softening hardened steel by heating it up to a definite temperature. *See* TEMPERING.

Leucine (*Chem.*) $\begin{matrix}CH_3\\CH_3\end{matrix}\!>CH.CH_2OHNH_2.COOH.$ White shining crystalline leaves with fatty feel; soluble in 48 parts of water at 12°, and in 800 parts of alcohol. Rapidly heated, it yields isoamylamine; but on carefully heating it can be sublimed unchanged. Nitrous acid replaces the amino group by OH. Ferric chloride gives a red colour with a solution of leucine.

It forms a characteristic copper salt. The leucine obtained from albuminoids by the action of acids is optically active; that obtained by the action of baryta water is inactive. Leucine is found in many parts of the body, and it is a constant decomposition product of albuminoids, *e.g.* on digestion, putrefaction, treatment with acids or alkalis. The best source is the cervical ligament of the ox. It is obtained from this as follows: The ligament is boiled with acetic acid and water till free from connective tissue; then with 1 part of sulphuric acid containing 3 parts of water for three hours; poured into sufficient milk of lime to neutralise the sulphuric acid; diluted with water, filtered, and washed. The filtrate is now boiled with milk of lime, again filtered, and neutralised. On concentration the leucine crystallises out. It is purified by boiling with animal charcoal and re-crystallising. Leucine has been synthesised from isobutyricaldehyde and hippuric acid, which yield α-benzoylamino-β-isopropylacrylic acid anhydride:

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CH.CHO + H_2C.N:C.OH.C_6H_5$$
$$\qquad\qquad COOH$$
$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CH:CH.\underset{|}{C}.N:\underset{|}{C}.C_6H_5 + 2H_2O.$$
$$\qquad CO - O$$

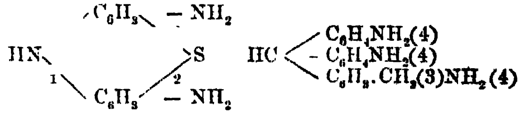
The acid corresponding to the above anhydride, on heating with excess of concentrated ammonia, yields benzoic acid, isovaleric acid, and leucine. Leucine contains an asymmetric carbon atom, so that it can exist in the dextrorotatory, the lævorotatory, and the racemic forms. Naturally occurring leucine is lævorotatory; the synthetic leucine is racemic. To split the racemic form it is converted into the benzoyl derivative by the Baumann-Schotten reaction (*q.v.*) This derivative, being much more strongly acid than leucine itself, can be united to an optically active alkaloid, such as strychnine or brucine, and the dextro and lævo salts separated by crystallisation. They yield the corresponding leucines on decomposition with an alkali. Leucine ethyl ester is prepared by passing hydrogen chloride into leucine in alcohol, decomposing the hydrochloride by an alkali, adding potassium carbonate, and extracting with ether. As this compound distils unchanged, it can be used to purify leucine. On being heated, the ester forms a piperazine derivative called leucinimide, which is 3 : 6—di-isobutyl—2 : 5—diketopiperazine:



a white crystalline solid, soluble in alcohol and melting at 276°.

Leucite (*Min.*) An aluminium potassium silicate, $K_2O.Al_2O_3.4SiO_2$. Alumina = 23·5, silica = 55, potash = 21·5. Cubic at 500° C., though at lower temperatures it shows double refraction and other anomalous properties. White to yellow grey. It is an important constituent of many of the more recent lavas, especially those of basic or sub-basic composition. It is allied in composition to some of the felspars, and is therefore often referred to as a felspathoid. It is of very rare occurrence in any lavas of earlier date than the later Tertiary period.

Leuco Compounds (*Chem.*) Colourless or only faintly coloured substances, which on oxidation yield dyes, and only differ from their oxidation products by containing two or more hydrogen atoms in the molecule than the dye, *e.g.*



Diamidothiodiphenylamine. Leuco Compound of Lauth's Violet (*q.v.*)

Para (3)-triamidodiphenylmetatolylmethane Leucaniline. The Leuco Compound of Rosaniline (*q.v.*)

Leucomaines (*Chem.*) A name given to an ill defined class of substances obtained from meat extracts. They are crystalline solids which produce vomiting, diarrhœa, and stupor. The commonest member of the class is called xanthocreatinine, and it has the formula $C_5H_{10}N_4O$—yellow leaves, bitter taste, basic in character; shows the amphoteric reaction (that is, turns blue litmus red; and red litmus blue). The constitution of the leucomaines is unknown.

Level (*Build, etc.*) *See* SPIRIT LEVEL.

—— (*Civil Eng.*) An open channel along which water flows, *e.g.* the Bedford level.

—— (*Mining*). An excavation, usually horizontal, along the course of a vein of ore.

—— (*Surveying*). An instrument for determining the relative heights of two points. Usually consists of a telescope capable of accurate horizontal adjustment which is used in conjunction with a graduated staff. The latter is held vertically on each of a series of stations, and observed through the telescope. The image of certain points in the graduation of the staff will coincide with the horizontal crosswire in the eyepiece, and the distance between these various points will be the difference of level of the stations.

Levelling (*Eng., Surveying, etc.*) (1) Making a surface horizontal. (2) Making a surface plane or flat. The latter is not a strictly correct use of the term, but it is commonly employed. (3) In surveying, the determination of the relative height of various stations.

Level Surface. A level surface may be defined as one parallel to the surface of a fluid at rest, *i.e.* one which is everywhere at right angles to the direction along which gravity acts.

Lever (*Mechanics*). A rigid bar turning about a fixed point termed the FULCRUM. A force is applied (usually transversely) at one point, and by means of the rigidity of the material is used to overcome a second force or resistance applied at a second point. The first force is usually termed the POWER, the second the WEIGHT; both terms are objectionable.

Lever Box (*Eng.*) The frame or box in which is fixed the axis of the levers used in controlling the motion of a crane.

Lever Escapement (*Watches*). A detached escapement in which the pallets, instead of being on the balance staff, are mounted on a separate arbor carrying a lever, by the fork of which impulse is communicated to the balance, and unlocking performed. *See also* RUBY PIN, ESCAPEMENT.

Lever Jack (*Eng.*) A small lifting jack, consisting of a support carrying the fulcrum of a simple lever, the short arm being applied to the weight to be raised, and the longer arm being moved by hand.

—— *or* **Locker Jack** (*Lace Manufac.*) An interceptor, used in lace curtain manufacture, that is brought into and out of action by the positive movement of a Locker bar.

Lever Safety Valve (*Eng.*) The form of safety valve (*q.v.*) used on most stationary boilers, in which the valve is kept down by a loaded lever, hinged at one end to the casting which carries the valve seat.

Lever's Machine (*Lace Manufac.*) One of the principal machines employed in the making of twist lace; invented by John Lever in 1813.

Lewis *or* **Lewisson** (*Build.*) A device attached to a hoisting chain for lifting blocks of stone.

Leyden Jar (*Elect.*) One of the earliest forms of electrical CONDENSER. It consists of a wide mouthed glass bottle or jar, the inside and outside of which are covered with tinfoil up to a certain distance from the top: these coatings form the two plates of the condenser, and can be charged up to a high difference of potential by an electrical machine; when discharged by momentarily connecting the coatings, a powerful spark may be obtained. To facilitate charging and discharging, the inner coat is connected to a metal rod projecting from the mouth or opening of the jar, and terminated by a metal sphere. The inner coating is now often formed by a metal lining, or even by a suitable quantity of some conducting liquid, such as sulphuric acid.

Li (*Chem.*) The symbol for LITHIUM (*q.v.*)

Lias (*Geol.*) The lowest subdivision of the Jurassic System. In Western Europe these rocks are chiefly of marine origin, and consist of alternate beds of clay and more or less argillaceous limestone, with some subordinate sandstones. Several well defined zones, each characterised by the occurrence within it of some particular species of Ammonite, form a remarkable feature of these rocks.

Libenthenite (*Min.*) A basic phosphate of copper, $4CaO \cdot P_2O_5 \cdot H_2O$. Orthorhombic; in dark green crystals and massive. Cornwall, Hungary, the Urals, etc.

Libration (*Astron.*) Variations in the inclination of the moon's axis which cause its poles alternately to incline towards and recede from the earth are called Librations in Latitude. Librations in Longitude are displacements at right angles to the above, due to variations in the moon's angular velocity round the Earth.

Lich Gate *or* **Lych Gate** (*Architect.*) A gate at the entrance to a churchyard under the roof of which the first portion of the Burial Service can be read.

Licker In (*Cotton Manufac.*) A saw toothed covered cylinder at one end of a carding engine, about 9 in. in diameter, which takes the cotton from the scutcher lap as it is fed, and transmits it to the wire filleted large cylinder for carding; sometimes termed "TAKER IN."

Liebermann's Reaction (*Chem.*) There are two totally distinct reactions known by this name: (*a*) In ordinary chemistry it refers to the Nitroso Reaction. When a nitrosamine (*see* NITROSO COMPOUNDS) or a nitrite is added to phenol in concentrated sulphuric acid, the liquid diluted, and an alkali added, a beautiful blue to violet coloration results. (*b*) In Physiological Chemistry it refers to a colour reaction for albumins. When a pure albumin is boiled with concentrated hydrochloric acid, a deep blue coloration is produced. The blue colours are not related chemically in the two reactions; in the latter it is probably chlormethylfurfuraldehyde which is the cause of the colour.

Lieblich Gedact (*Music*). Small scale gedact (*q.v.*)

Lierne Rib (*Architect.*) A rib used in Decorated Gothic architecture as an ornamental feature in the rib and panel vaults. It lies in the vaulting surface between the ridge ribs and the ribs springing from the imposts, and divides the vaulting surface into panels. *See* RIB AND PANEL VAULT.

Lierne Vaulting (*Architect.*) Vaulting containing Lierne Ribs (*q.v.*)

Lievrite (*Min.*) An iron calcium silicate, $H_2O \cdot CaO \cdot 4FeO \cdot Fe_2O_3 \cdot 4SiO_2$. Orthorhombic; also massive; black. From Elba, the Harz, Saxony, Norway, the United States, etc.

Life (*Eng.*) The period during which an object may be kept in actual use, or, in the case of objects only used intermittently, the number of separate times it may be used.

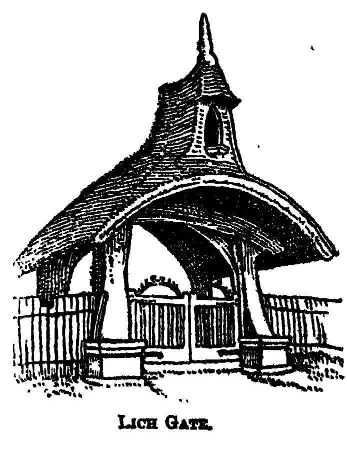
Lifebuoy Signal. *See* HOLMES' SIGNAL.

Lift. An appliance for raising weights through a vertical distance, *e.g.* from floor to floor in a building; it may be actuated by hand or by machinery of some description, acting by means of ropes or cables, or may be directly connected to the ram of a hydraulic press having a cylinder of length sufficient to raise the weight the required distance.

—— (*Foundry*). The upper portion of a mould, which is raised to enable the pattern to be withdrawn after it has been moulded.

Lift Bridges (*Civil Eng.*) A bridge with a roadway which can be raised bodily from its supports. It is a somewhat unusual type; the largest is in Chicago, where a roadway of 50 ft. width is carried over a span of 130 ft., and can be raised to a height of 155 ft. by steel cables running in vertical steel towers at each end of the bridge.

Lifter (*Foundry*). A moulder's tool used for extracting loose



LICH GATE.

sand from a mould; the term is applied also to iron hooks fixed so as to support the sand in the upper or LIFT portion of the mould.

Lifting (*Foundry*). (1) The process of removing the upper part of the mould or of withdrawing the pattern itself. (2) The bursting of the top of a mould through the pressure of the fluid metal.

Lifting Blocks. PULLEY BLOCKS (*q.v.*)

Lifting Plate (*Foundry*). Iron plates let into and fastened to a pattern; they have tapped holes into which iron rods or handles termed LIFTING RODS or SCREWS can be fixed to aid the withdrawal of the pattern.

Lifting Screws (*Foundry*). *See* LIFTING PLATE.

Lifting Shutters (*Carp. and Join.*) Window shutters hung on cords like sashes.

Lifting Straps *or* **Irons** (*Foundry*). Strips of thin iron attached to a pattern to serve as handles in withdrawing it from the sand.

Lift Pump. The ordinary suction pump for raising water a distance not exceeding 30 to 32 ft.; as a rule, 25 ft. is regarded as the limit. The lift pump in its simplest form consists of a cylinder fitted to a tube placed in a reservoir of water. A valve opening upwards covers the opening of the tube at its junction with the cylinder. In the cylinder is placed a piston worked by means of a lever—the pump handle. The piston is also fitted with a valve opening upwards. When the piston is raised its valve, owing to atmospheric pressure, remains closed, the lower valve opens, and air (or water) is sucked into the cylinder. When the piston descends, its valve opens, and the lower valve closes. As the atmospheric pressure on the surface of the water in the reservoir is constant, it drives up the water into the tube; each stroke causes a further rise in the water level, until ultimately it reaches the spout and escapes. *See also* PUMPS.

Lift Valve (*Eng.*) A disc or cup just fitting the valve opening or seat; it rises vertically, and so forms a passage round its edge. The valves of gas engines, most pumps, etc., are usually lift valves.

Ligature (*Typog.*) Type consisting of two or more letters joined together and cast on one body, *e.g.* ff, fi, ffi, fl, ffl.

Light. That portion of the radiant energy transmitted by wave motion through the ether (*q.v.*) which produces the sensation of sight when it falls on the retina of the eye, or which is capable of producing an image by its action on a photographic plate. *See also* INTENSITY, INTERFERENCE, POLARISATION, REFLECTION, REFRACTION OF LIGHT.

—— (*Build.*) (1) A general name for any kind of window. (2) The name given to each perpendicular space or division of a window that is separated by mullions.

Light Carburetted Hydrogen (*Chem.*) *See* METHANE.

Lighthouse (*Civil Eng.*) The term lighthouse is usually applied to a lofty permanent structure erected on a rocky or solid foundation in the vicinity of some dangerous point of the sea coast. It is provided with a powerful light at the top, and the necessary accommodation for a staff of men, and frequently with bells, syrens, and other signalling apparatus.

Lightning (*Meteorol.*) When the air between two clouds charged with electricity, or between a charged cloud and the earth, is subject to an electrical strain, and the strain cannot be resisted, a disruptive electrical discharge occurs, and lightning is the result.

Lightning Arrester (*Elect. Eng.*) A device for protecting electrical apparatus from the effects of lightning. In most forms a conductor connected to earth is placed in close proximity to conductors which are included in the circuit; the atmospheric discharge occurs across the air gap so formed, rather than along the main wires of the circuit. In many cases this discharge would start a dangerous arc across the gap; hence most arresters have some automatic device for extinguishing it. The earthed conductor sometimes possesses a series of projecting points, forming a COMB ARRESTER.

Lightning Conductor (*Meteorol.*) A broad ribbon of copper running from the earth to a point or set of points projecting above the summit of a building. The base should be connected to a large mass of metal or some other conducting substance buried in the earth.

Light Petroleum (*Chem.*) LIGROIN (*q.v.*)

Light Railway (*Civil Eng.*) Local or branch lines constructed in a cheaper manner than ordinary railways, and often running along or beside an ordinary road.

Light Ratio (*Astron.*) The absolute scale adopted for star magnitudes (*q.v.*)

Light Running (*Eng.*) (1) Machinery is said to be "light running" when the friction at the bearings is reduced to a minimum. (2) The term is also applied to machinery when the load or work done is much below its usual value.

Lights (*Painting, etc.*) Those parts of a picture where the light appears to be most brilliant; any illuminated surface or object as represented in a picture. *See also* CHIAROSCURO.

Lightship (*Civil Eng.*) A strongly built vessel anchored near shoals or rocks, and carrying a powerful light, thus serving as a lighthouse. It is constructed so as to roll as little as possible in rough weather, in order that the light may be steady.

Light Year (*Astron.*) The unit of distance adopted in stating the distances of stars, since the diameter of the earth's orbit is too small to serve as a unit. The length of this unit is about sixty-three thousand times the distance of the earth from the sun.

Lignin *or* **Lignine** (*Botany*). The constituent of the cell walls of the elements of wood and bast fibres. It is probably a mixture of several compounds.

Lignite (*Geol.*) A variety of coal in which the vegetable tissues have lost only a small part of their component oxygen and hydrogen, the process of conversion being incomplete. *See under* COAL.

Lignum Vitæ. *See* WOODS.

Ligroin (*Chem.*) The fraction of American petroleum which comes over on distillation between about 90° and 120°. It consists chiefly of paraffin hydrocarbons containing from 6 to 8 carbon atoms; and it is used chiefly as a solvent for organic substances.

Liliaceæ (*Botany*). One of the largest Monocotyledon orders, cosmopolitan in distribution, and varied in habit. It includes the Onion, Shallot, Garlic, and Asparagus among food plants; others yield fibres, resins, and drugs, while the purely ornamental members of the order are very numerous.

Limb (*Astron.*) The edge of the disc of the moon, sun, or a planet.

Limbus (*Archæol.*) The rim of a crater or wine-cup.

Lime (*Botany*). A variety of the citron (*Citrus medica*; var. *acida*; order, *Rutaceæ*), producing the well known fruit and beverage. *See* CITRUS *and also* WOODS.

—— (*Chem.*) A popular name for calcium oxide. *See* CALCIUM COMPOUNDS. It is also used in combination, as in the popular names CHLORIDE OF LIME (bleaching powder, *q.v.*), MILK OF LIME (calcium hydroxide in water), QUICK LIME (calcium oxide), SLAKED LIME (calcium hydroxide), and SUPERPHOSPHATE OF LIME (a mixture of calcium acid phosphate and calcium sulphate).

Lime Blast (*Leather Manufac.*) A stain on leather due to the lime on the skin or hide having become carbonated, owing to exposure to the air or to washing in hard water. Forms dark cloudy stains on finished leather.

Lime Blue (*Dec.*) This is an almost obsolete pigment. Its colour is due not to lime, but to copper. The lime is really a filling. The manufacture consists essentially in precipitating sulphate of copper solution with ammonia, adding more ammonia so as to redissolve the blue precipitate of cupric hydrate, and then gently heating with milk of lime. A precipitate consisting of a mixture of calcium sulphate and hydrated copper oxide is gradually formed; this is filtered off, washed, and dried at a low temperature. The ammonia may be generated by the lime, and to do this sal-ammoniac is first added to the sulphate of copper. More milk of lime is then required, as calcium chloride is formed as well as sulphate, and takes no part in the formation of the pigment, being washed away in the filtration. Care must be taken that only very moderate heat is used in making lime blue; high temperatures blacken it. Lime blue has the faults of all copper pigments—*viz.* being poisonous and turning black on exposure to the air of towns. Ultramarine is often passed off as lime blue.

Lime Light. *See* OXYHYDROGEN FLAME.

Limestones (*Geol.*) Rocks, usually of organico-chemical origin, which consist essentially of carbonate of lime in a solid state, formed chiefly in the sea, but in some cases also in fresh water. Their origin is due in large measure to the vital action of animals or of plants, which convert solutions of other lime compounds, especially the sulphate, into the carbonate, this being eventually left in the solid form. The waste products also of these organisms, living or dead, set up chemical reactions upon the lime salts in solution around them, and thus cause precipitates of carbonate of lime, which are added to the organically formed constituents, and serve to form the compound under consideration.

Lime Water (*Chem.*) *See* CALCIUM COMPOUNDS.

Liming (*Leather Manufac.*) To remove the hair from skins and hides, they are soaked from one to three weeks in a mixture of lime and water. This liming swells the skins, and enables the hair to be removed by hand or machine. *See also* LEATHER MANUFACTURE.

Limit of Elasticity. *See* ELASTIC LIMIT.

Limma (*Sound*). The ratio of two notes of frequency, 16 and 15, *i.e.* the interval $\frac{16}{15}$.

Limoges Enamels. *See under* ENAMELS.

Limonene (*Chem.*) *See* TERPENES.

Limonite (*Min.*) A hydrate of iron, $2Fe_2O_3 . 3H_2O$. It occurs in mammillated forms having a radiating structure, or more often in crusts and amorphous masses. Light yellow to black. Streak always brownish yellow. As clay ironstone it is much used as an ore. Of very wide distribution.

Linalool (*Chem.*) (Dimethyl—2 : 6—octadien—2 : 7—ol—6) $(CH_3)_2\ C : CH . CH_2 . CH_2 . COHCH_3 . CH : CH_2$. For the name see NOMENCLATURE. A colourless liquid smelling of May blossom; boils at 194°—198°; it contains one asymmetric carbon atom, and its dextro, lævo, and inactive forms are all known. Dilute sulphuric acid converts it into terpinhydrate, while glacial acetic acid and sulphuric acid convert it into terpineol. On oxidation it yields methyl-heptenone and then lævulinic acid (*q.v.*) Linalool occurs in many sweet smelling oils, *e.g.* free in oil of lavender, oil of linaloes (from white cedar of Cayenne), coriander oil, etc.; and as acetate in oil of lavender, oil of bergamotte, etc. It is best obtained by fractional distillation of oil of linaloes. Used in perfumery. *See also* TERPENES.

Linarite (*Min.*) Basic lead and copper sulphate, $PbO . CuO . SO_3 . H_2O$. Monosymmetric. It occurs in crystals of a characteristic blue colour, as the result of the decomposition of other lead ores. A rare mineral. From Cumberland, Leadhills, Spain, etc.

Linch Pin. A pin put through a transverse hole in the axle of a vehicle to prevent the wheel coming off.

Line. (1) A mathematical conception, having length and direction, but no breadth or thickness. (2) A nautical term for the EQUATOR (*q.v.*) (3) A unit of measurement equal to $\frac{1}{12}$ of an inch; now rarely used.

—— (*Art*). Contour, outline, method of rendering form. In pl. the word signifies DESIGN; the distinctive features in a design or in the composition of a picture, apart from the colouring.

—— (*Linen Manufac.*) The best portion of the flax after it is hackled or combed. Sometimes the points and root ends are cut off, leaving only the centre portion, which is the most valuable. It is then called "CUT LINE."

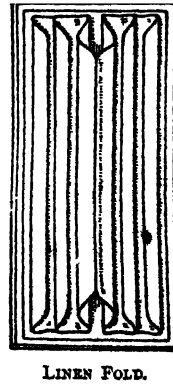
Linea Elastica (*Phys.*) *See* ELASTICA.

Line and Pins (*Build.*) A long line attached to iron pins. Used for keeping the courses in a brick wall straight.

Linear Velocity. The velocity or speed with which a body moves along a path whether straight or curved, as distinguished from ANGULAR VELOCITY (*q.v.*)

Line Engraving. *See under* ENGRAVING.

Linen Fold (*Architect.*) An ornament used on panels, and resembling the folds of linen. It was introduced late in the Perpendicular style. *See* DORSE.



LINEN FOLD.

Linen Manufacture. Linen is made from the fibrous inner bark of the *Linum usitatissimum*, whence it takes its name. The common name of the plant is "Flax," from the Dutch

Vlasch or German *Flachs.* It is probably the oldest textile fabric in existence, and was much esteemed by the ancient Egyptians, who were skilled in its manufacture thousands of years before the Christian era. Drawings representing the various processes of manufacture are to be found depicted on their tombs, and it was regarded as an emblem of purity because it was not eaten by moths, did not rend easily, neither was it furnished by any animal subject unto death, as silk and wool were. The plant has a wide range, and may be found in the burning plains of Egypt as well as in the frigid Russian climate; but a temperate climate is most suited to the growth of a good fibre. The plant is now largely cultivated, both for its fibre and seed, in Holland, Belgium, France, and Ireland, also in Russia, where large quantities of a coarser description are grown. The best flax comes from Courtrai, where the water of the River Lys is particularly suited to retting it. A moist temperate climate favours its growth, and when properly grown it is a very pretty crop, with its long slender stalks about $2\frac{1}{2}$ or 3 ft. long, terminating with bunches of delicate blue flowers. When it is considered ripe enough, it has to be carefully pulled and tied up in bunches. It is then "rippled" to clear the seed off, and may be either dried and stacked, as on the Continent, or at once steeped, as is done in this country. The steeping or "retting" of the flax consists of placing it in large dams of stagnant water, where the gummy matters binding the fibres together and to the stem of the plant ferment, and are dissolved away. This allows the fibrous portion to be easily stripped from the stem. The time required to effect this varies considerably with the temperature, but about ten or twelve days will usually be sufficient. As soon as fermentation ceases, the retting process should be carefully watched, as it is very important, in order to avoid waste in the subsequent processes, that the flax should be just sufficiently retted and not overdone. When sufficiently steeped, it is taken out of the steep hole and allowed to drain, and afterwards spread on grass fields to dry and get the sun and atmosphere, which completes the steeping process, and enables the fibres to be more readily separated. This process is called "grassing" or "crofting," and usually occupies from six to ten days according to the weather, fine weather with occasional showers being the best. When sufficiently grassed and dry, it is gathered up and bound into sheaves. It may then be stacked or taken to the scutch mill for "scutching." Scutching consists of beating out the bone or stem of the plant and leaving the fibres. This is usually done by holding the flax in handfuls over upright pieces of flat iron, close to which strong wooden blades fastened on a shaft are rapidly revolved. The handfuls of flax are turned till they are quite clean, with only the fibre remaining. Many methods have been tried with the view of superseding retting and scutching, which are very primitive processes, but they have not been very successful. When scutched, the flax is sent to the markets, where it is purchased for the spinning mills. The flax has now to be manufactured into yarn and cloth, and the first process is to comb the flax in order to free it from all short and twisted fibres and separate all bunches of fibres that may be sticking together. The combs consist of a number of pins fixed in a block of wood, and the flax is drawn in handfuls over these till it is quite straight and clean. The combs vary in fineness; the first, called a rougher's tool, is strong, with the pins set wide apart, and the work is called "roughing." The finer hackling used also to be done by hand, but is now done by machinery. The bunches of flax, suspended by one end, are combed by steel combs fastened on an endless chain beginning with medium coarse combs, and passing on over finer ones till it is finished. When one end of the flax is combed, it is turned, and the other end combed likewise. Sometimes this completes the hackling, but more frequently it undergoes a still finer process of hand hackling over very fine combs. This is called sorting, as the men who comb the flax separate it into parcels of different degrees of fineness. Sometimes the flax is used the full length of the fibre, sometimes it is cut across. When dressed, the flax is called "line," and if cut it is called "cut line." The combings from the line and the ends cut off it all go as tow, and are carded and spun for tow yarns. The line is now ready to be prepared for spinning. SPINNING MILLS are usually divided into "dressing," "preparing," "spinning," and "reeling" departments. The preparing includes the various processes necessary to make the flax into a "rove" ready for spinning. The first thing to be arranged is the mixture of flax to be used to make a yarn of the quality required. It is then taken to the spread boards, where it is spread out in small parcels overlapping each other and drawn forward on revolving bands to a set of rollers, which press the parcels of flax together, and form them into a flat tape sufficiently firm to hold together. At the same time that the flax is being drawn forwards a number of small combs called "gills" are made to rise up through it, and on the other side of these a second set of rollers, revolving more quickly than the first ones, draw out the band of flax through the gills and make it a finer and more uniform tape than it otherwise would be. This tape of flax is called a "sliver." The sliver is now very much thicker than would be required for spinning into yarn, and also if spun in this way would make a very irregular thread, the thicks and thins being caused by overlapping the small parcels of flax when spreading them out, and by reason of these parcels not being exactly alike in thickness. A thread made by twisting this first sliver would be very irregular in thickness, and to overcome this difficulty several slivers are next run together (called doubling), and are then drawn out greatly in length, the operation being repeated until the resulting sliver is pretty well equalised in thickness. At the last drawing and doubling it gets a slight twist, and is wound on large bobbins in a frame called a "roving frame." This completes the "preparing" process, and the rove is ready to be spun. FLAX YARN is spun on two systems, which are much alike in principle, though they vary considerably in detail. In both, the spinning is done on the throstle or fly frame, the principal difference being that in one case the rove is spun dry, whereas in the other it passes through water of varying degrees of heat before it reaches the drawing rollers, according to the quality of yarn to be spun. It then passes on to the spindles and flyers, where it gets the requisite amount of twist, and is wound on a bobbin. The process is the same when the rove is spun dry, but when spun wet the fibres of flax are more easily drawn on each other, and the machinery must be arranged to suit the requirements of both cases. When the bobbins are full, they are cleared off and empty ones put on the spindles by little girls called "doffers." When wet spun, sometimes the

yarn is dried on the bobbins and used in this state for making cloth, but more frequently the bobbins are sent to the reeling rooms to be reeled into hanks. The reels are large cylindrical frames, 90 in. in circumference, and 6 or 8 ft. long, fixed to revolve in a horizontal position, and a number of threads from bobbins set on pins at certain distances apart are attached to these, and the turning of the reels winds the yarn on them from the bobbins. Every 120 revolutions winds 300 yards of yarn from each bobbin round the reels, and this is one "cut," and is separated or marked from the next one by twisting a piece of twine round it. When twelve of these cuts are wound on the reels, they are full, as twelve cuts make one hank, and this is the way the yarn is put up. The hanks are now taken off the reels and sent to the drying loft, where they are dried on poles. After this they are made up into bunches of 3, 6, 9, or 12 bundles, each bundle containing 60,000 yards of yarn, or 16 hanks and 8 cuts; sometimes, however, there are only 10 cuts put to a hank, and then 20 of these hanks are required to make a bundle. It is by the bundle the yarn is sold. The fineness of wet spun linen yarn is reckoned by the number of cuts there are in 1 lb., but the fineness of dry spun yarn is usually reckoned by the weight of the "spindle" or "spangle" of 4 hanks; thus if a spindle of yarn weighed 2 lb. it would be called 2 lb. yarn. WEAVING: Linen yarn is frequently woven in the raw or "green" state and bleached afterwards; but as there is a great loss of weight from bleaching, the yarn for heavy cloths must be reduced in some way before they are woven. This is usually accomplished by boiling in alkalis, which makes a reduction of 10 to 15 per cent. The weaving of linen is conducted much in the same way as cotton weaving, but the yarn will not bear friction so well, though it is much stronger. It has very little elasticity, so that it requires strong machinery and all friction reduced as much as possible. Sometimes the yarn is used from the spinner's bobbins, but frequently in the hank state. It has to be wound on spools and warped on beams in the usual way, and then may be run from these on to the weaver's beam if strong yarn and in the green state, otherwise it must be dressed. "Dressing" is brushing the yarn over with some sort of a glutinous mixture, such as flour paste, to strengthen it, and lay all the loose fibres on its surface. Sizing or boiling in starch, as is practised in the cotton trade, does not do for linen yarn. The dressing is applied cold, and all the threads of yarn kept separate and not allowed to stick together. The yarn is run on to the weaver's beam in the dressing machine. The cloth is then woven, the greater portion of it being made into plain texture, though twills, fancy textures for towellings, and damasks for table linens also constitute a considerable part. A great quantity of unions are also made, as they are cheaper than pure linen, but are not equal to it in quality or strength. These are often termed "linen," and sold as such. When woven, the linen is either finished in the brown or loom state, or it may be bleached and dyed. It does not take dyes so well as many other fibres, and the colours, especially rich ones, look rather poor on it; but some shades of colour suit very well No fabric bleaches to such a rich pure white, and this, with its durability, if properly made, are its premier qualities. The linen trade in this country has its principal seats in and around Belfast in Ireland, and Dumfermline in Scotland. Originally Dublin used to be the centre of the Irish linen trade, but the trade worked northwards, and Dublin has but little of it left. All cloth made from flax or linen yarn is, broadly speaking, linen; but speaking definitely or in technical terms, only cloth of a plain texture, or with the warp and weft threads passing over and under each other alternately, is called linen.—T. F. B.

Linen Scroll. *See* LINEN FOLD.

Line of Action. The mathematical line (*q.v.*) along which a force is exerted.

Line of Continuation (*Music*). A horizontal line following the figures in a figured bass to indicate that the preceding harmony is to be continued for so long as the line of continuation is placed.

Liner (*Dec.*) A sable brush having a square top and hair about 2 in. long, used by coach and carriage painters for drawing lines on various parts of coaches. The term is also applied to a tool used by house painters, made of hoghair bristles set in tin ferrules, and usually called FITCHES. When made with a bevelled edge they are intended for drawing straight lines in decoration, and are then termed liners.

—— (*Eng.*) A tubular piece of metal placed inside a bearing, cylinder of an engine, etc., to compensate for the wearing away of the original surface.

Line Shafting (*Eng.*) The principal shafting running through a factory, from which the subsidiary shafts (countershafts, etc.) are driven.

Lines of Force. If a small electrically charged body perfectly free to move in any direction be placed in an electric field, it will move along a continuous definite path, which is usually a curved line. The tangent to the curve drawn from any point on the curve is the direction along which the electric force is acting at that point, and the whole line is termed a LINE OF FORCE. In a magnetic field similar lines of force may be drawn for the direction along which a single magnetic pole tends to move. The main properties of lines of force are as follows: (1) They run from a positive charge (or pole) to a negative one, always starting from one kind of charge (or pole) and finishing at another. (2) They converge or approach each other (though they never cut nor touch) in the parts of the field where the force is stronger, and diverge where the force is weaker. The number of lines in any part of the field may be taken as proportional to the force at that place. (3) The actual number of lines is not finite, since we may imagine a line running through every point in the space occupied by a magnetic field; but we may adopt any convenient convention connecting the number of lines and the actual electric or magnetic force at any point. This is settled by the units employed. The accepted system implies that both unit pole and unit charge correspond to 4π lines of force, magnetic and electric respectively. From this it follows that the electrical force at a point *in air* is equal to the number of electrical lines of force passing through a unit area surrounding the point, and at right angles to the lines, the same relation being true also for a magnetic field. If the medium is not air, its SPECIFIC INDUCTIVE CAPACITY (*q.v.*) or PERMEABILITY (*q.v.*) has also to be taken into account. (4) The lines are everywhere at right angles to the EQUIPOTENTIAL SURFACES; hence electrical lines of force ending on or starting from a conductor always cut its surface at right angles. (5) The arrangement of the lines is affected by the nature of the medium through which

they run. If a portion of material which has a higher SPECIFIC INDUCTIVE CAPACITY than the surrounding material be introduced into an electric field, lines of force crowd into it from other parts of the field; similarly the magnetic lines crowd into material of higher PERMEABILITY (*q.v.*), such as iron, when placed in the field.

Lingoes (*Silk Manufac.*) Lead drawn out to a form of wire or cable, cut into lengths of 7 to 10 in., varying in weight from 12 to 80 to the pound, and attached as weights to the lower ends of couplings carrying the MAILS in FIGURED HARNESS (*q.v.*)

Lining, Marking, *or* **Setting Out** (*Eng.*) Marking on a casting, etc., the principal points, centres, and lines from which the dimensions of the finished work are to be measured.

Lining Paper (*Dec.*) A white paper for hanging on walls and ceilings, as a foundation for the pattern paper.

Lining Papers (*Bind.*) *See* END PAPERS.

Linings (*Join.*) A general name in joinery for the internal work, finishings, etc., in a building.

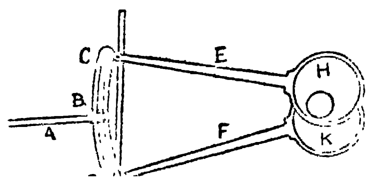
—— (*Met., etc.*) A coating of various refractory materials, such as fireclay, which is placed over the inner surface of furnaces, foundry ladles, etc., to prevent their destruction by fluid metal.

Link (*Eng.*) (1) Any connecting piece in a machine. (2) The slotted bar connected to the ends of the eccentric rods in LINK MOTION (*q.v.*)

—— (*Surveying*). *See* WEIGHTS AND MEASURES.

Linking Up (*Eng.*) *See* LINK MOTION.

Link Motion (*Eng.*) The reversing device used for working the slide valve in locomotives, marine engines, etc. The valve rod A, one end of which is attached to the slide valve, terminates at its other end in a block B, which slides in a slotted LINK CD. To the ends of this link are connected the rods E and F, to the ends of which are fixed the ECCENTRICS H and K (*q.v.*) The link CD can be raised or lowered by a system of levers attached to the link, so that either the upper eccentric rod E or the lower one F is in line with the valve rod A. Either eccentric can thus be made to drive the valve rod, the other one merely producing an oscillatory motion of the link which does not affect the valve rod; and if the two eccentrics are so fixed that they drive the valve in opposite directions (relatively to the stroke of the piston), then the engine can be reversed by raising or lowering the link, so that either E or F is in line with the rod A. In the position shown, termed MID GEAR, the valve remains at rest; by setting the link in an intermediate position, with the block B between the middle and end of the link, the time of cut-off, and therefore the expansion of the steam, can be varied; this is known as LINKING UP or NOTCHING UP. In GOOCH'S LINK MOTION the link is fixed, and B is connected to the valve rod by a hinged connecting rod: in this form the link CD is curved in the opposite direction. In ALLEN'S LINK MOTION a hinged valve rod is also used; when reversing, the link and the connecting rod are each moved in opposite directions: in this case the link CD is straight.



LINK MOTI

Linotype Composing Machine. *See under* TYPE SETTING MACHINES.

Linseed. The seed of the flax plant; much used for feeding cattle and for making linseed oil, linseed meal, etc.

Linseed Oil (*Dec., etc.*) The oil chiefly used by painters and decorators. *See* OILS.

Linstock (*Arms*). A pike, generally with branching arms on either side, shaped to hold the lighted match for firing the cannon; it also served the cannoneer as a weapon of defence. The linstock was used first in the sixteenth century; it sometimes consisted merely of a staff with a pointed end, for sticking in a deck or in the ground, the other end being fashioned to hold the match.

Lint. A name frequently applied to flax or the flax plant: also linen scraped into a soft substance, used for dressing wounds.

Lintel (*Build.*) The horizontal member of wood or stone forming the top or head over a door or window opening, and supporting the masonry or brickwork above.

Lion (*Her.*) The lion ranks first among the animals used in heraldry, and appears on many Royal shields. It is blazoned in numerous attitudes, each bearing a particular appellation. The teeth and claws are called their "arms"; they are generally armed gules unless otherwise specified.

Lioncels (*Her.*) When more than three lions are borne on one shield they are called "lioncels."

Lion Combattant (*Her.*) Two rampant lions placed facing each other; when back to back they are ADDORSED.

Lion Couchant (*Her.*) At rest or lying. The four legs stretched out on the ground head erect, facing dexters.

Lion Coward (*Her.*) As passant reguardant, but with tail between his legs. The crest of Arthur Tudor Prince of Wales was a lion coward.

Lion, Demi Rampant. The forequarters of a lion with the upper portion of its tail.

Lion Dormant (*Her.*) Asleep, head resting on or between forepaws, which are extended on the ground.

Lion Passant (*Her.*) The position of the lion when walking towards the dexter. Three paws on the ground, the fourth (dexter forepaw) raised; the tail curved over the back, and head looking straight in front.

Lion Passant Guardant (*Her.*) Similar position of body to passant, but with head facing spectator or affronté. *See* LEOPARD. Old armorists term the above a LEOPARD.

Lion Passant Reguardant (*Her.*) The same as passant, but with the head turned, looking back towards the sinister.

Lion Queue Fourchée (*Her.*) Having two tails, or double queued.

Lion Rampant (*Her.*) Stands erect on his hind-legs, with one of his forelegs elevated above the other; the tail is also elevated and the head in profile. The red lion in the royal arms of Scotland is a lion rampant.

Lion Rampant Guardant (*Her.*) Similar to rampant, only the head placed affronté—*i.e.* with the face towards the spectator.

Lion Rampant Reguardant (*Her.*) The same position as rampant, but with the head turned back or contourné—*i.e.* looking behind him.

Lion Salient (*Her.*) In the act of leaping or about to spring, hindlegs together on ground, forelegs together extended.

Lion Sejant (*Her.*) A lion sitting on his haunches, head erect, facing dexter.

Lion Statant (*Her.*) Standing on the four feet, the head in profile looking towards dexter; tail extended. The crest of the Duke of Northumberland is a lion statant.

Lion Statant Guardant (*Her.*) The same as statant, but with head affronté; tail extended, as in the well known crest of the Howards.

Lip (*Eng., etc.*) (1) The bent mouth of a ladle. etc. (2) A point or other part of the cutting edge of various tools.

Liparite (*Geol.*) A semi-crystalline rock of the type emitted as lava from the principal volcano of the Lipari islands. It agrees in chemical composition with that of the granites, and, like that rock, normally contains alkali felspar (usually Orthoclase) and some free quartz. Its highly cellular (or frothy) varieties form PUMICE, while its compact vitreous varieties are distinguished as OBSIDIAN. Plagioclase felspars, and one or more of the ferro-magnesian silicates, such as Biotite or Hornblende, may also be present, but in small proportion to the rest.

Lipase (*Chem.*) An enzyme which occurs in fresh pancreatic juice, in castor-oil seeds, linseed, poppies, etc. It has the property of resolving fats into glycerine and fatty acid, also of hydrolysing many other esters. Its action has been shown to be reversible; it can bring about the reunion of the alcohol and acid to reproduce the ester.

Liquefaction of Gases (*Phys.*) All the gases, with the possible exception of certain newly discovered and very rare elements, can now be liquefied. The essential feature of the methods in use consists in subjecting the gas to a sufficiently low temperature. Carbon dioxide, which can easily be liquefied by pressure alone at ordinary temperatures, since its critical temperature (*q.v.*) is 31° C., is commonly used to furnish one step in the production of cold. By allowing the liquid CO_2 to evaporate rapidly, solid CO_2 can be obtained, which, when mixed with ordinary ether (*q.v.*), forms a liquid whose temperature falls to − 77° C. If a vessel full of ethylene (*q.v.*) be immersed in this liquid, the gas becomes liquefied, and the liquid ethylene, on being allowed to evaporate, falls to a temperature of about − 150° C. To obtain the still lower temperatures necessary for the liquefaction of oxygen and nitrogen, a "regenerative" method is employed. The gas is compressed in a receiver which is strongly cooled; a stream of this gas is allowed to flow through a coiled tube surrounded by a jacket, the outside of which is maintained at a low temperature. At the end of the spiral is a small outlet, the size of which can be regulated by a valve. As the gas escapes from this orifice it expands, and in so doing becomes cooled. It then flows up through the jacket, and still further cools the spiral tube. Thus the stream of gas flowing through the spiral becomes colder and colder, until at last it is cooled down to its point of liquefaction, and drops of the liquid collect in a vessel placed beneath the outlet at the end of the spiral. Still lower temperatures may be obtained by utilising the rapid evaporation of gases liquefied by this method, and hydrogen may be liquefied and even solidified. It is believed that if liquid HELIUM (*q.v.*) could be produced in quantity, a temperature within 5° C. of the absolute zero could be attained.

Liquid. A liquid is a FLUID (*q.v.*) which is distinguished from a gas by the fact that it occupies a definite volume, whatever be the size of the vessel in which it is contained, and it always possesses a definite surface, which is horizontal when at rest.

Liquid Driers (*Dec.*) *See* DRIERS.

Liquids, Elasticity of (*Phys.*) Liquids show VOLUME ELASTICITY only (*q.v.*): that is, they do not offer resistance to forces tending to change their shape. *See* ELASTICITY OF VOLUME.

Liquorice (*Botany*). A demulcent drug derived from the fresh or dried rhizome of the plant *Glycyrrhiza glabra* (order, *Leguminosæ*).

Liriodendron (*Botany*). *L. tulipifera*, the tulip tree, belongs to the *Magnoliaceæ*. It is a native of North America, and is of value for its wood. *See* WOODS.

Liroconite (*Min.*) A hydrous basic aluminium and copper arsenate of very complex composition. Monosymmetric. Of a beautiful blue green colour. From Cornwall, Hungary.

Lisiere (*Silk Manufac.*) *See* LIZIER.

Lissajou's Figures (*Sound*). Figures produced by a spot of light, after reflection from two mirrors which are describing simple harmonic vibrations along two paths at right angles to one another. The mirrors are usually fixed to the tips of two large tuning forks, and the spot of light is either allowed to fall on a screen or observed through an eye-piece.

Listel (*Architect.*) *See* FILLET.

Listing (*Textiles*). *See* SELVEDGE.

Litharge (*Chem. and Dec.*) A common name for lead monoxide. *See* LEAD COMPOUNDS *and* DRIERS.

Lithia Mica (*Min.*) A synonym for LEPIDOLITE, (*q.v.*)

Lithium, Li (*Chem.*) Atomic weight, 7. A silvery white metal; melts at 186°. It is the lightest solid known (sp. gr. ·59); burns with bright white flame on being heated above its melting point in air; water converts it into the hydroxide, but much less energetically than in the case of sodium or potassium. Lithium has a characteristic spectrum consisting of one line in the red, and one weak line in the yellow; by means of its spectrum a quantity of lithium less than $\frac{1}{1000000}$ milligramme can be detected. On account of the extreme delicacy of this test it has been shown that lithium is a widely distributed element—thus, it occurs in sea water, in many mineral springs, in the ashes of many plants, *e.g.* in tobacco ash. The chief minerals containing it are triphyline (*q.v.*), petalite (*q.v.*), lepidolite (*q.v.*), and spodumene (*q.v.*) The metal is obtained from its chloride by electrolysis either of the fused chloride or of its solution in pyridine, using a carbon anode and an iron or platinum cathode. Lithium belongs to the same group of elements as sodium and potassium (Group I. of the Periodic System). Its salts bear a general resemblance

to those of sodium and potassium, the more notable differences being as follows: its chloride is strongly deliquescent, its sulphate does not form an alum, its carbonate and phosphate are far less soluble in water. Lithium salts (carbonate and citrate) are used in medicine for gout, because lithium biurate is a fairly soluble salt.

Lithography. The art or process of drawing or writing on a special kind of stone, or transferring drawings, designs, or writing to such stone, for the purpose of reproduction in ink. The process was discovered by Aloys Senefelder at Munich about 1798. Lithographic stones consist of a compact homogeneous slaty limestone, presenting a very smooth surface when polished. Suitable stones are obtainable from many countries, but the best come from Bavaria, the country where the discovery of the process was made. When the design has been produced upon the stone with special ink or chalk (or transferred to the stone), the surface of the stone is etched by means of a mixture containing about two parts of nitric acid, the ink or chalk design being unaffected by the etching medium. The result is that the design is elevated above the surface of the stone to an almost imperceptible degree. The next process before printing is the removal, by means of a solvent, of the whole of the material employed to effect the design. The stone is then wetted. The *design* is unaffected by the water and is capable of receiving printing ink from the roller, whereas the etched portion when damp will not take up the ink. The desired impression can then be obtained by passing the stone through the press. CHROMO-LITHOGRAPHY requires the employment of as many different stones as there are various tints or colours, one stone being printed from after another upon the same sheet, the whole of the printings when completed fitting and blending together and giving the required result. Much success in colour printing has recently been obtained by ALGRAPHY, a process in which aluminium is substituted for the lithographic stone.

Lithopone (*Dec., etc.*) The name given to a white pigment of Continental manufacture, of which Orr's Zinc White (*q.v.*) is the prototype. Also spelled LITHOPHONE.

Litmus (*Chem.*) Rounded or cubical blue granules consisting chiefly of chalk and gypsum, and containing only a little of the real colouring matter. The colouring matter occurs in various lichens (*Roccella tinctoria*) which grow in Norway, Sweden, the Canary Islands, and on the shores of the Mediterranean Sea. The lichens are dried, powdered, and allowed to ferment for several weeks in presence of urine or ammonia. During the fermentation a substance, ORCIN, is formed, among many others. The orcin, in presence of air and ammonia, forms ORCEIN, which yields litmus by further fermentation in presence of ammonia. The colouring matter so obtained is mixed with chalk and gypsum. Litmus is a mixture of substances, the true colouring agent being a substance called AZOLITHMIN, of unknown constitution. Azolithmin is a dark brown amorphous solid, sparingly soluble in water, insoluble in alcohol, soluble with blue colour in alkalis, insoluble in strong acids. It can be prepared from commercial litmus by extraction with cold water, acidifying with hydrochloric acid, and evaporating with sand to dryness. The dry powder is spread upon large filters, and washed successively with hot and cold water, and again dried. The dry powder is now washed with hot water containing a little ammonia. The solution, which now contains the azolithmin, is neutralised, and it is ready for use. The azolithmin can be obtained from it by diluting and acidifying with sulphuric acid, when the colouring substance is precipitated. Good litmus solution is a very sensitive indicator for acids and alkalis; but alkaline carbonate must be titrated boiling, so that carbon dioxide, which reacts acid to litmus, does not remain in solution. Litmus solution kept in closed bottles changes in colour, owing to the action of anærobic bacteria; it regains its colour on access of air, or will retain it in a closed bottle if a little thymol is added. Litmus papers are prepared by soaking unglazed paper in litmus solution, rendered just alkaline for blue papers and just acid for red papers, and afterwards drying.

Litre. *See* WEIGHTS AND MEASURES.

Little Masters (*Art*). The term applied to a group of German artists of the sixteenth and seventeenth centuries, so called from the smallness of the prints they executed. They were chiefly influenced by Dürer, and included amongst their number Aldegrever, Burgkmair, and Altdorfer.

Littoral Conditions (*Geol.*) The geographical conditions which occur in the zone extending from high water mark outwards to a depth of a few fathoms. It is generally understood to refer to the marginal zones of the sea; but it is not infrequently applied also to the marginal zones of lakes. The Littoral zone is usually regarded as the belt over which marine life is most fully developed, and it also coincides with the chief zone of marine erosion.

Littoral Deposits (*Geol.*) Rock materials which have been formed or have accumulated close to the shore line, in contradistinction to PELAGIC or THALASSIC deposits formed under conditions of deeper water. They are usually either sands and gravels, or else their compacted equivalents, sandstone and conglomerates. They are generally characterised by containing the vestiges of shore animals and plants.

Lituus (*Archæol.*) The staff or wand, with one end curling round, used by Roman augurs. The prototype of the bishop's crozier.

Live (*Elect. Eng.*) A conductor is said to be live or alive when a current is flowing in it, or when it is at a high potential.

—— (*Eng.*) A moving part of a machine is sometimes termed live or alive in contradistinction to the fixed parts.

Live Load (*Eng.*) A weight or load on a structure which varies either as regards amount or position.

Live Ring (*Eng.*) A circular channel under a TURNTABLE (*q.v.*), in which are a number of rollers, called LIVE ROLLERS, which support the weight of the table, and thus form a kind of large roller bearing; a similar device is used with large revolving cranes.

Live Steam (*Eng.*) Steam which has not been expanded, as distinguished from exhaust steam.

Lixiviation (*Chem.*) The process of extracting, by a suitable solvent, the soluble product of a chemical change which has been effected in a substance or mixture of substances by heating to a high temperature. The solution obtained is often called a LYE. For an example *see* the Leblanc Process, *under* ALKALI.

Lizier, Lisiere, *or* **Edge** (*Silk Manufac.*) The selvedge of a cloth, usually made either gros or twill, and warped on a bobbin separate from warp roll. It is frequently striped in a special arrangement of colours, by which certain qualities and makes of cloth are known.

Load (*Elect. Eng.*) The output, in watts, required from a dynamo or other electrical plant or machinery, *i.e.* the electrical power which the plant is required to furnish to the circuit which it supplies.

—— (*Eng.*) (1) The weight supported by a structure. (2) The power furnished by an engine, etc., under any given circumstances.

Load Curve (*Elect. Eng.*) A curve showing the total power furnished at each period or instant throughout the day.

Loading. A term signifying the addition of china clay and other minerals to pulp in order to produce a paper suitable for printing illustrations, *i.e.* an ART PAPER.

Loadstone. *See* LODESTONE.

Loam (*Build.*) A mixture of sand and clay.

—— (*Foundry*) A mixture of sand, clay, and some material of a fibrous nature, used for making cores or forming moulds by the use of a loam board or striking board, instead of by the use of a pattern. Occasionally a LOAM PATTERN is made and used instead of an ordinary wooden pattern; this process is used in the case of large objects of circular section, and the pattern is formed in much the same way as a core.

Loam Board (*Foundry*) A board whose edge is cut to the contour or outline of some casting; it is used for forming a core, loam mould, or loam pattern, in lieu of using a wooden pattern. A simple cylindrical casting, large iron piping, etc., can be moulded in this way, the core being formed separately and inserted in the ordinary way. A loam mould requires to be dried artificially before the metal is poured.

Loam Brick (*Foundry*) A block of dried loam used in building up the larger portions of a loam mould.

Loam Mill (*Foundry*) A kind of mortar mill used in the foundry for grinding and mixing loam.

Loam Mould (*Foundry*) *See* LOAM *and* LOAM BOARD.

Loam Pattern (*Foundry*) *See* LOAM.

Lochrian (*Music*) *See* MODES.

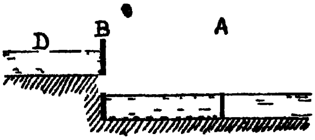
Locker. A strong box, chest, or compartment secured by a lock; a small cupboard, especially one under a seat.

Locker Rack (*Civil Eng.*) *See* MOUNTAIN RAILWAYS.

Lock Nut (*Eng.*) A thin auxiliary nut screwed on the top of an ordinary nut to prevent the latter from working loose.

Lock Rail (*Joinery*) The rail of a door on which the lock is fixed. Usually the middle rail.

Locks (*Civil Eng.*) A device used for transferring a vessel between two parts of a stream, canal, or harbour, at different levels. Two lock gates, A and B, enclose a space E, whose bottom is on a level with the lower part of the channel. To pass a vessel from C to D, it is first admitted by opening the gate A, the water being made level in E and C by a sluice in A. The gate A and the sluice are closed, and a sluice in B opened until the water in E is level with that in D, when the vessel can pass into the upper channel. Locks are always used when there is an adequate supply of water in the upper part of the channel.



LOCKS

Lock Saw (*Carp., etc.*) *See* KEYHOLE SAW.

Loco (*Eng.*) A common abbreviation for LOCOMOTIVE.

—— (*Music*) In the pitch as written, used after 8ve or 8va bassa, to show that the written pitch is to be resumed.

——, **Loco Plant, Loco Weed** (*Botany*) A leguminous plant (a species of *Astragalus*, found in the west and south-west of the United States. When eaten by cattle it causes *loco disease*, an affection of the brain.

Locomobile (*Motor Cars*) A name given to a light class of steam cars of American make.

Locomotive (*Eng.*) Usually a railway engine; also applied to traction engines (*q.v.*), certain forms of motor car (especially steam cars), and to electric motors mounted on an independent vehicle for drawing electric trains.

Locomotive Boiler (*Eng.*) *See* BOILERS.

Locomotive Crane (*Eng.*) A power crane capable of running along a line of rails propelled by its own engine.

Loculus, *pl.* **Loculi** (*Archæol.*) A small chamber or recess in ancient tombs for the reception of a body or an urn. *See* CATACOMB.

Lodes (*Geol. and Mining*) Originally a Cornish miners' term for mineral veins containing one or more of the ores of the metals, and now used in that sense generally. The lodes usually occupy the intervening space between the opposite walls or "cheeks" of a fissure. In nearly all cases this fissure constitutes part of a fault or dislocation, of the country rock on one side relative to that on the other. The ores, and their accompanying gangue or "rider," usually occur in a very irregular and sporadic manner throughout the height and length of the lodes, and their extent in a longitudinal direction generally much exceeds that from below upwards.

Lodestone *or* **Loadstone** (*Elect.*) The natural magnet, consisting of the oxide of iron, Fe_3O_4, or MAGNETITE (*q.v.*). The word lodestone means "leading stone," from its power of acting as a compass needle, and "loadstone" is an incorrect spelling.

Lodgings (*Hygiene*) *See* HOUSES LET IN LODGINGS.

Loess (*Geol.*) A geologically recent deposit of loam, occurring over wide areas in some parts of Europe, and on a still more extensive scale in China. In the latter country the Loess appears to be a deposit which has arisen from the long continued deposition of dust transported from desert regions by the wind. It is considered by many persons that the European Loess is due, in like manner, to dust deposited under steppe conditions. The brick earths of the south-east of England are supposed by many to have been formed in this way, but the fact that they contain large boulders, and show evidence of crumpling, such as is produced by floating ice, seems to render that view untenable.

Log. A LOGARITHM (*q.v.*)

—— (*Carp., etc.*) A large piece of timber, either in its original shape or roughly dressed by the axe, but not sawn.

Logarithm. A COMMON LOGARITHM of a number is the index of the power to which the number 10 must be raised to give the number; thus 10 must be cubed or raised to the power 3, to give 1,000; hence the common logarithm of 1,000 is 3. The number 10 is called the BASE of the common logarithms. NATURAL or NAPIERIAN LOGARITHMS are calculated to a different base, the series denoted in mathematical books by *e*. The sum of this series is 2·71828 . . . The natural logarithm of a number can be found by multiplying the common logarithm (taken from tables of logarithms) by 2·30258.

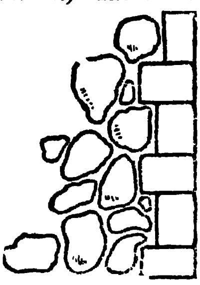
Loggia (*Architect.*) An arcade on the façade of a building, forming a gallery open to the air on one side.

Logotype (*Typog.*) Two or more letters in their normal form, or sometimes a word, cast on one body. *Cf.* LIGATURE (*Typog.*)

Logwood (*Botany*). The dye substance HÆMATOXYLIN (*q.v.*) is found in the heartwood of the stem of *Hæmatoxylon pechianum* (*Leguminosæ*). *See also under* DYES AND DYEING.

Long (*Music*). *See* NOTES.

Long and Short Work (*Architect.*) The name given to the ashlar quoins used in the rubble walling of Anglo-Saxon work. The quoins were formed of flat and upright courses alternately. *See* BLOCK AND START.



LONG AND SHORT WORK.

Long Column (*Eng.*) A column of material whose length is more than twenty times its diameter. Such a column gives way by bending, whereas a short one gives way only by crushing.

Longitude, Celestial (*Astron.*) *See* LATITUDE AND LONGITUDE, CELESTIAL.

——, **Libration in** (*Astron.*) *See* LIBRATION.

Longitudinal Elevation. A side view of a structure.

Longitudinal Section. A view showing a section through an object from end to end.

Long Letters (*Typog.*) Letters extending above or below the alignment of the small letters, *e.g.* b, f, g, h.

Long Primer (*Typog.*) Type of a size between small pica and bourgeois. *See* TYPE.

Longwall System (*Mining*). *See* MINING.

Loofah (*Botany*). The loofah, used as a natural flesh brush, consists of the vascular network of the fruit of a plant of the cucumber family, *Luffa ægyptica* (order, *Cucurbitaceæ*).

Loom. The machine used for combining and interlacing the warp and weft threads so as to form cloth. Each loom is fitted up to suit the particular class of work required—that is, either with a tappet, dobby, or Jacquard shedding motion. A loom with one shuttle box at each end of the sley is called a plain or stripe loom, and would only admit of one colour or thickness of weft being inserted with the warp. This combination would be called a plain or a stripe cloth, according to the weave. Some looms are fitted up with more than one shuttle box at the end of sley, and are termed multiple box or check looms. These are capable of producing various coloured patterns in the cloth, known as check cloths. A loom is lightly or heavily constructed to suit the class of work which it is required to produce. The hand loom is very seldom used in the cotton trade, except for pattern weaving and experimental purposes. Power looms are worked in factories principally by steam motive power, and for good working a steady motion is requisite. The power loom is automatic so far as regards its essential movements for the production of cloth, which are: (1) Opening the shed or making a division in the warp threads for the shuttle to pass through; (2) picking through the shuttle, which carries the weft; (3) beating up the weft. The first is accomplished by the shedding motion; the second by the picking motions, which are of two kinds—*viz.* (*a*) overpicks, (*b*) underpicks; the third by the crank and sley each time a pick of weft is inserted by the shuttle. Auxiliary motions in the form of taking up and weft stop motions are also attached, these being absolutely necessary for the production of perfect cloth. The taking up motion automatically regulates the closeness of the weft threads or picks as the cloth is woven, and to a certain extent determines the quality. The weft stop motion immediately stops the loom if the weft in the shuttle breaks or becomes exhausted before the weaver perceives it. The recognised practice in the trade at the present time in England is for a weaver to attend from four to six looms, the duties being to replenish the weft in the shuttle as it becomes exhausted during weaving, piece up broken warp threads, and attend to other minor details. Efforts are now being made by some manufacturers to get weavers to attend from six to eight looms by attaching a warp thread stop motion to each. With this system a weaver must depend on the efficiency of the stop motion to produce perfect cloth. Several forms of automatic shuttling or shuttle changing motions are now being tried for plain work. No results of a definite character have yet been arrived at in England, although a large number are in operation in America. The new motion allows a weaver to attend from twelve to twenty looms. A considerable amount of skill is taken from the weaver and put into the loom mechanism. The following are the chief automatic weft supply looms on the market: (1) Northrop, (2) Hattersley, (3) Harriman, (4) Baker Kip, (5) Cowburn. DESCRIPTION OF ORDINARY POWER LOOM.—The warp beam C is placed in brackets behind the loom. All the warp threads are passed over back rest rail D in a broad sheet and split up by lease rods E, which serve to keep the threads in their proper order, before they pass through the eyes in healds 1 and 2. For a plain weave the threads would be drawn alternately through the eyes on healds 1 and 2, and again passed through the reed F, two threads in a dent or split, which is held in position by sley G and handrail H, they in turn being secured to sley sword L, working on rocking rail M as a fulcrum. When the warp is in process of interlacing with the weft, the cloth will be formed at K and pass over the breast beam N round feed roller P, and on to cloth roller R. The whole stretch of warp from C to N is kept at suitable tension by chains and weights round the warp beam C. An oscillating

motion is imparted to the sley by means of connecting rod S from crank T, which is on the main driving shaft of the loom. Immediately below the crank shaft is fixed tappet shaft V, on which are placed the plain tappets or cams A and A'. This shaft only makes one revolution for two of the crank shaft, consequently the tappets come in contact with their own levers B and B' alternately. The simple operation of weaving is performed as follows: As the tappets A and A' revolve, they operate on levers

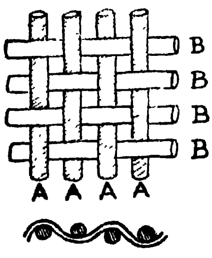


Fig.

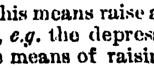


Fig. 3.

B and B', and by this means raise and depress healds 1 and 2 alternately, *e.g.* the depression of lever B and heald No. 1 is the means of raising heald 2 through top roller W. All threads drawn through the eyes of healds No. 1 are raised, and all threads drawn through the eyes of healds No. 2 are depressed. By this means

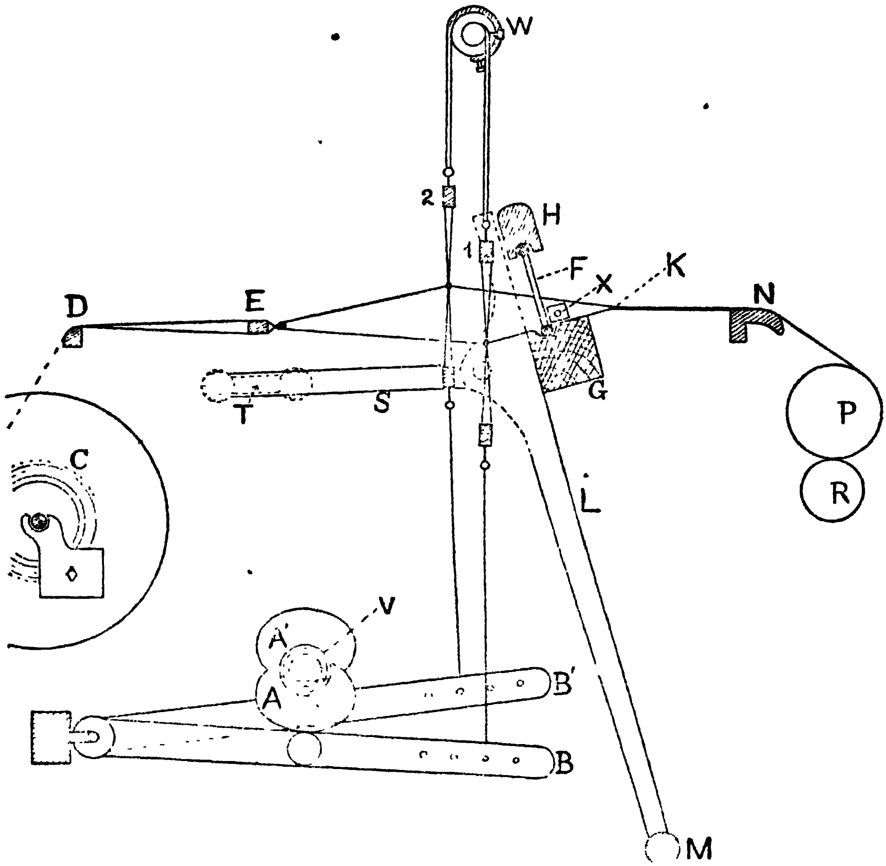


Fig. 1.

a "shed" is formed, and when full open the shuttle X carrying the weft is "shot" or "picked" through. By the time the shuttle has passed through the shed and reached the box on the other side of sley, the loom crank will have moved the sley to its most forward position, and by means of the reed the weft will be forced to the "fell" of the cloth at K. Before

Fig. 4.

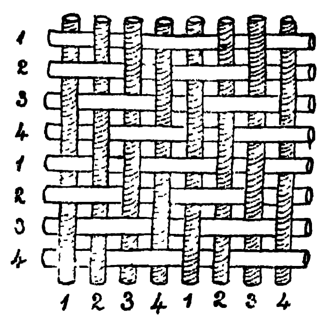
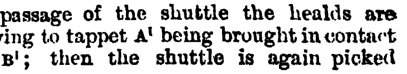


Fig. 5.



the return passage of the shuttle the healds are reversed, owing to tappet A' being brought in contact with lever B'; then the shuttle is again picked

through, and the weft afterwards beaten up as before. The fact of all odd threads being lifted when even threads are down, and *vice versâ*, each time a "pick" of weft is inserted, enables a woven cloth to be produced which is very firm and strong, considering the amount of material which may be put into it. The ordinary method of "darning" gives one an idea of a plain weave, a diagram in plan being here given at fig. 2 and a section at fig. 3. When the warp threads are required to be put closer together in the reed, and a different method of interlacing is required, such as a twill weave, more shafts of healds are necessary. This involves the use of differently constructed tappets, which are mostly worked from counter shafts, actuated from the tappet shaft V or by special gearing from the crank shaft at one end of the loom. A three end twill would require a three leaf tappet, a four end twill would require a four leaf tappet, and so on. Fig. 4 shows enlarged weave plan of a four end twill, produced by a four leaf twill tappet, working four healds in succession for two picks up and two down. Fig. 5 is sectional view showing one pick of weft intersecting with warp threads. Small figured weaves are usually produced by means of the dobby machine, the tappets being dispensed with. When the patterns to be produced are beyond the capacity of the dobby, then the Jacquard machine is used.

Looming (*Meteorol.*) An appearance allied to MIRAGE (*q.v.*), by which distant objects become visible at a greater altitude than their true one, or actually inverted, over their actual position. It is probably due to a layer of hot and rarefied air some distance above the level of the ground.

—— (*Textile Manufac.*) *See* LOOM.

Loop Yarn (*Textile Manufac.*) A fancy yarn on which curls or loops are formed on the twisting frame. It is a yarn extensively used in fancy fabrics, and also in fabrics with a curly surface.

Loors (*Mining*). Fine material or sludge left as refuse from the washing of tin ores.

Loose Centres (*Eng.*) Supports resembling a pair of POPPET HEADS (*q.v.*), used to hold cylindrical objects while marking out, or while certain operations are being carried out in the planing or slotting machine.

Loose Coupling (*Eng.*) A coupling (*q.v.*), which can readily be disengaged or thrown out of gear.

Loose Eccentric (*Eng.*) An eccentric which rides loose on the shaft, but is prevented from turning completely round by two fixed stops. When in contact with one of these it drives the engine forward; by bringing it in contact with the other stop the engine is reversed.

Loose Gland (*Eng.*) A ring used for making a watertight joint in iron piping. It serves to force a rubber ring into the socket, and is kept in place by bolts.

Loosening *or* **Rapping** (*Foundry*). Tapping a pattern which is being moulded in order to loosen it slightly in the sand and facilitate its withdrawal.

Loosening Bar (*Foundry*). A bar of iron used for loosening or rapping a pattern.

Loose Pieces (*Foundry*). Parts of a complicated pattern which can be detached from the main portion to facilitate withdrawal from the mould.

Loose Pulley (*Eng.*) A pulley which can turn freely on its shaft; it is placed alongside a fixed or driving pulley, so that the driving belt can be shifted on to it when the machinery driven by the belt is to be stopped.

Lorry. A flat truck.

Loss (*Eng., etc.*) A part of the energy supplied to a machine which is dissipated by friction and is not converted into useful work.

Lost Ampères (*Elect. Eng.*) The portion of the current generated by a Shunt dynamo, which flows through the coils of the field magnets instead of through the external circuit. In a good machine this portion is usually only a very small fraction of the total current generated.

Lost Volts (*Elect. Eng.*) That portion of the total E.M.F. generated in a Series dynamo which is required in order to send the current through the coils of the field magnets. The voltage thus lost is very small in a good machine.

Lost Wax Process (*Founding*). A method of bronze founding in which a core is covered with a wax model of an object of which a casting is required, the wax being made of the same thickness as it is intended the metal shall be. When the model is complete, the wax is covered with a porous clay, and the whole baked in a pit; the wax, of course, melts during the process, and runs off through openings left for the purpose. The space that was occupied by the wax now forms the mould for the metal.

Lotus Capital (*Architect.*) Three types of Egyptian capital—the campaniform, the clustered lotus bud, and the plain lotus bud capitals—were derived from the lotus flower in different stages of development. The outline of the plain lotus bud capital is similar to that of the clustered lotus bud capital, but its horizontal section is a circle, whereas that of the latter is a series of convex segments. *See* CLUSTERED LOTUS BUD CAPITAL, CAMPANIFORM CAPITAL, HATHOR HEADED CAPITAL, *and* PALM CAPITAL.

Lotus Flower (*Architect.*) An Egyptian water lily. This flower, conventionally treated, was freely used in Egyptian architecture.

Louver (*Archæol.*) A domed turret or lantern with lateral openings, fixed on the roof of the hall in a mediæval building in order to carry off the smoke which rose from the open hearth.

—— *or* **Louvre** (*Build.*) Strips of wood or other material running across an opening, the plane of each strip being inclined to the vertical plane, and its lower edge overlapping the strip below it, but not touching it. The spaces thus left between the strips are available for ventilation, but rain, etc., is excluded. Used for shutters, ventilators, etc. The spelling LOUVRE is incorrect, though it is commonly used.

Louvered Ventilator (*Build.*) A frame with inclined boards, strips of glass, or other material (louvers), arranged so as to admit air but exclude rain. *See also* LOUVER.

Louvre. The name of the palace in Paris in which are placed many of the finest examples of art possessed by the French nation.

—— (*Build.*) The common spelling of LOUVER (*q.v.*)

Low (*Meteorol.*) A term generally applied to cyclone centres in contradiction to HIGH, the centres of anticyclones.

—— (*Print.*) Used to imply that parts of a printed sheet do not show up clearly, *e.g.* in the case of worn type. *Cf.* HIGH.

Lower Case (*Typog.*) The case that contains the small letters and spaces. *Cf.* UPPER CASE.

Lowestoft (*Pot.*) A small manufactory of porcelain was established at Lowestoft about the year 1756. The wares produced were never of high standard or of great importance. So-called "Lowestoft" china is almost invariably of Chinese manufacture. The factory was closed about 1804. Lowestoft china is of poor quality, and the ornamentation of it is slight and inferior.

Low Flash Oil. Oil whose vapour becomes spontaneously ignited at a comparatively low temperature. *See* FLASHING POINT.

Low Moor Iron (*Met.*) One of the best qualities of wrought iron, made at Low Moor in Yorkshire.

Low Pressure Cylinder (*Eng.*) The larger cylinder of a compound engine, in which the steam undergoes its final expansion before escaping. *See* STEAM ENGINE.

Low Red Heat. A temperature of about 1300° F. (700° C.)

Low Relief (*Sculp.*) *See* BAS-RELIEF.

Low Warp. Tapestry in which the warp (*q.v.*) takes a horizontal position during the process of weaving. This facilitates its manufacture, but the result is not supposed to equal high warp tapestry. *See* HIGH WARP.

Lozenge (*Her.*) A diamond shaped, four sided charge set perpendicularly on a shield. The shield of an unmarried woman or of a widow is of this shape. A shield divided by diagonal lines crossing forms a pattern called lozengy.

Lozenge Moulding (*Architect.*) An enriched moulding, used in Norman architecture, consisting of a repetition of lozenge shaped forms.

Lubricants. The theory of lubrication is the interposition between two surfaces which rub together (by reason of the motion of one or of both of them) of a substance which has a smaller co-efficient of friction with both the surfaces concerned than they have one with another. Lubrication, then, is using something to diminish friction, and therefore waste of power, and, what is of even more importance, heating of the surfaces and possible consequent seizure from expansion and stoppage or breakage of the machinery. Experience has shown that fats and petroleum are the best lubricants, with certain special exceptions, the chief of which is graphite, used for wooden gearing which would absorb grease or a liquid lubricant. To know what lubricant to use in a given case is very important, and many different kinds and combinations have been tried for various purposes, with the result that a large number of lubricants are in use. The prime requisite of a lubricant is that it shall diminish friction, as above stated. It follows from this that drying oils such as linseed or poppy oil, which become sticky and resinous by exposure to the air, are unsuitable. The lubricant must remain between the surfaces during the motion. Hence for heavy bearings a thicker lubricant is required than for light ones, which, although they would diminish friction more, would be squeezed out from the bearing. The speed at which the axle is driven has also an important influence on the choice of a lubricant. Other things being equal, the higher the speed the thinner and less in specific gravity must the lubricant be. The factor of time comes in here. A very heavy but slow running axle can be and must be fed with a comparatively viscid lubricant, and there is time to overcome the cohesion of the oil particles so that they slide over one another and over the lubricated surfaces. If the same axle were run at a high speed, internal stresses would be developed in the oil layer, the overcoming of which would necessitate a large amount of power. It will now easily appear that it is difficult to find a good lubricant for heavy axles run at a high speed, and that in any case a compromise must be effected, and the lubricant fitted as nearly as may be both to the weight and to the speed of the axle. Of course, light, fast running axles, such as cotton mill spindles, are easily provided for, as are heavy and slow moving axles. Another important point is the temperature at which the lubricant has to do its work. This is why oils for bearings are so different from the oils used for lubricating pistons and stuffing boxes in steam and gas engines. It is quite evident, to begin with, that an oil which might be too viscid at ordinary temperatures might be just right or even too fluid when subjected to the heat of steam or gas explosion. Again, the chemical constitution of the lubricant must not undergo an injurious change, owing to the temperature or the action of steam or hot gases. Steam is a most energetic chemical reagent at high temperatures. One effect of high temperatures is to carbonise the fat. If that happens, the function of lubrication is seriously interfered with, and in a gas engine carbonisation is extremely likely to happen. High pressure steam decomposes fats into glycerine and fatty acids, whereby not only is a part of the lubrication lost, but chemical action ensues between the fatty acid and the lubricated surfaces which soon leads to clogging and imperfect fitting. The glycerine is carried away into the exhaust. It is obvious that for high temperatures oils and fats are quite unsuitable, and no better lubricants are known for cylinders than heavy petroleum oils. These are extremely stable chemically, have low co-efficients of friction, and are fluid enough at the high temperatures with which they meet. They cannot turn acid, and are as free from chemical action, whether on steam or anything else, as can be desired or hoped for. Many cylinder oils on the market are mixtures of mineral oil with ordinary fat. These should be shunned, as the presence of the mineral oil does not prevent the occurrence of the difficulties above detailed as a result of the action of high temperatures on animal or vegetable fats. The dark cylinder oils are an intermediate fraction of petroleum, the light oils having been removed by distillation, and the solid ingredients of the mineral oil by cooling. They vary greatly in usefulness, as well as in colour and consistency. They have a low specific gravity, averaging about ·9, and a high flash point (260° to 285° C.) The pale cylinder oils have a higher specific gravity (about ·925), and a considerably lower flash point (often as low as 220° F.) They are inferior to the dark oils in all respects. As regards the tests of a cylinder oil, it should, in the first place, contain no volatile constituents. Its weight ought to remain constant at the boiling point of water or somewhat higher for

many hours. The heaviest oils evaporate slowly below their boiling points, but even after thirty-four hours at 110° C. the loss should be less than 1 per cent. The flash point should be fairly high, not less than about 250° C., and the viscosity must be considerable, and should not be greatly lessened by the temperature that is known to prevail in the cylinder to be lubricated. Theoretically the specific heat should be as high as possible; but the point is of no practical importance, seeing the small differences between the specific heats of different oils, mineral or otherwise, and the small quantities that are used. As regards lubrication at ordinary temperatures, graphite or talc is most useful for very heavy, slow running axles. Both should be mixed with a solid or liquid fat, according to the temperature of the workshop. Tallow is excellent for warm shops. Lard, tallow, castor oil, heavy petroleum oils, or mixtures of them all answer well. Probably any vegetable or animal fat is improved by petroleum, as the mineral oil keeps the bearings clean. In this connection it may be mentioned that all fats must be scrupulously freed from every trace of membrane or tissue if they are to be used as lubricants. Such impurities are especially common in solid fats, and a number of samples should be examined under the microscope on a heated stage. When the fat on the slide is fused, any fragments or skin can be at once detected, and show that the stuff is unfit for use. For high speeds under heavy pressure, rape and lard oils are largely used, generally mixed with heavy or light petroleum oils, according to the working temperature. For rapid, light running machinery, sperm oil is the favourite lubricant, but olive and rape are much used, both alone and mixed with the lighter petroleum oil. In general, two different lubricants should be used for a machine, for it is almost invariably the case that different parts of it run under different pressures and at different speeds.

Lubrication (*Cycles*). An exposed chain is best treated with finely crushed graphite or black lead, freed from grit and well rubbed on. All other parts should be lubricated with any good machine oil.

Lubricator (*Eng.*) A receptacle for lubricants. It may be a simple vessel communicating with the bearing, etc., by a tube or channel, or it may be supplied with some device for pouring or forcing a stream of oil into the bearing.

Ludlow Rocks (*Geol.*) A general term for the upper third subdivision of the Silurian Rocks, taken from the name of the town where these rocks were first studied. Of late years the extended study of the rocks on this horizon has led to the suggestion that their classification should be remodelled, and that the term DOWNTONIAN, which is preferable for many reasons, should be employed, in place of the older name, for all the rocks from the top of the Ledbury Shales to the base of the Leintwardine Flags which underlie the Aymestry Limestone. The Lower Ludlow Shales are thus left in another division, which is termed the SALOPIAN.

Lug (*Eng.*) A projecting portion of a casting, etc., by means of which it can be fixed in position, *e.g.* by bolts passing through.

—— (*Plumb.*) *See* EAR.

Lugs (*Cycles*). *See* CYCLES.

Luminosity (*Phys.*) (1) The power of giving out light. (2) The amount of light furnished by a particular source.

Luminous Paint (*Chem.*) A paint which emits light in a dark room. If some bits of phosphorus are allowed to stand in olive oil in a bottle which is kept in a warm place for two or three days, the oil dissolves a little phosphorus, and when it is painted on an object, the latter is visible in a dark room, and will remain visible till the phosphorus is oxidised. A totally different paint may be made by mixing various phosphorescent sulphides or oxides with oil, and using this as a paint. *See* BOLOGNIAN PHOSPHORUS *and* CALCIUM SULPHIDE.

Lunar Bows (*Meteorol.*) *See* RAINBOWS.

Lunar Caustic (*Chem.*) A common name for SILVER NITRATE. *See* SILVER COMPOUNDS.

Lunar Distances (*Astron.*) A method of determining longitude by means of the measurement of the apparent distances of stars from the lunar disc.

Lunation (*Astron.*) The time between one new moon and the next. *See also* SYNODIC MONTH.

Lunette (*Architect.*) A window formed in a domical ceiling.

Lunga Pausa (*Music*). Long pause.

Luni-Solar Precession (*Astron.*) A slow retrograde motion of the equinoctial points upon the ecliptic. *See also* PRECESSION.

Lusingando (*Music*). Coaxingly, tenderly.

Lustre. A large ornamental chandelier.

—— (*Min.*) The lustre of minerals is a property of importance in classification. Six varieties of lustre are usually referred to. They are:

(1) METALLIC (Galena or Pyrites).
(2) VITREOUS or glassy (Quartz, Rocksalt).
(3) RESINOUS (Amber, Pitchblende).
(4) PEARLY (Talc).
(5) SILKY (Fibrous Gypsum).
(6) ADAMANTINE (Diamond).

Lustring *or* **Lutestring** (*Silk Manufac.*) A plain silk fabric woven as tabby, the weft used being bright, to give lustre.

Lute (*Met.*) Refractory material, such as fire-clay, used for making a close joint in furnaces, covers of crucibles, etc.

Lutestring (*Silk Manufac.*) *See* LUSTRING.

Lutidines (*Chem.*), $C_5H_3(CH_3)_2N$. A name given to the dimethyl pyridines, of which there are six; some of them occur in bone oil. *See* PYRIDINE.

Luxembourg. The Palace of the Luxembourg in Paris contains an Art Gallery, in which are exhibited works by many famous modern artists.

Lychees (*Botany*). The Chinese plant *Litchi chinensis* (order, *Sapindaceæ*) produces an edible nut containing a fleshy aril around the seed. The fruit in a dried state is imported into this country.

Lych Gate (*Architect.*) *See* LICH GATE.

Lycine (*Chem.*) Another name for BETAINE (*q.v.*)

Lycopodium (*Botany*). A fern plant *Lycopodium clavatum* (order, *Lycopodiaceæ*), with a superficial mosslike appearance ("Club moss"). The resinous spores are used in medicine and as a coating for pills. In Sweden doormats are made from the plants.

Lydian (*Music*). *See* MODES.

Lye (*Chem.*) A very general term for various solutions used in chemical trades, *e.g.* a solution of an alkali. *See also* LIXIVIATION.

Lying Press (*Bind.*) A strongly made press actuated by two screws, used for various purposes, *e.g.* holding a book while the edges are being cut or while the back is being shaped.

Lymphatics (*Zool.*) A system of vessels which traverse the body, finally passing to the large veins near the heart. Their function is to carry back to the blood the waste products of the tissues.

Lysine (*Chem.*), *ae*-diaminocaproic acid, $CH_2NH_2CH_2CH_2CH_2CHNH_2COOH$. A white crystalline solid obtained among a large number of other products on boiling albumins with concentrated hydrochloric acid. It is dextrorotatory. According to some it is the parent substance of the ptomaine Cadaverine, which forms when dead bodies putrefy.

Lysol (*Chem.*) A disinfectant consisting of a solution of crude cresol in soft soap.

M (*Elect.*) Commonly used as a symbol for MAGNETIC MOMENT (*q.v.*)

m (*Elect.*) A symbol commonly used for the strength of pole (*q.v.*) of a magnet.

μ (*Elect.*) The symbol for PERMEABILITY (*q.v.*)

—— (*Phys.*) The symbol for a MICRON, the thousandth part of a millimetre.

$\mu\mu$ (*Phys.*) The symbol for the millionth part of a millimetre, *i.e.* a thousandth of a MICRON (*q.v.*)

Ma (*Music*). But, *e.g. Ma non troppo*, but not too much.

Macabre (*Art.*) A term applied to a subject in which there occurs a representation of Death, *e.g.* in the form of a skeleton, etc.

Mace (*Archæol., etc.*) A staff or bludgeon, and originally the special weapon of prelates and of the King's sergeants-at-arms. A brass in Wandsworth parish church of one Nicholas, a sergeant-at-arms of Henry V., is unique in showing the mace suspended from his girdle in the place generally occupied by the misericorde. Most corporate bodies now possess a mace, used as an insignia of office, and borne before the chief officials, *e.g.* mayors. The mace belonging to the House of Commons always rests upon the table in front of the Speaker during his presence in the House. When he leaves the Chair and the House goes into committee, the mace is placed beneath the table.

Maceration. The term applied when vegetable or other substances are softened in a liquid. This process is used to separate the fibres of plants for textile purposes and in tanning. *See* LINEN MANUFACTURE, LEATHER MANUFACTURE, *etc.*

Machicolations (*Architect.*) *See* CORBEL TABLE.

Machine. An assemblage of inter-related movable parts, forming an appliance for transmitting and modifying forces and the motion produced by them. The relative motions of the parts are definitely controlled or "constrained."

—— (*Elect. Eng.*) The term machine is commonly applied by electrical engineers to dynamos, electric motors, rotary converters, boosters of all kinds, and occasionally transformers, though the latter are not, of course, machines in the mechanical sense of the word.

Machine Cut Pattern (*Foundry*). An iron pattern used for casting toothed wheels, the teeth of the pattern having been cut by a revolving cutter. Such a pattern can give a very clean casting, in which the teeth need little or no trimming.

Machine Cutters (*Eng.*) Usually applied to the revolving cutters used in milling machines, as distinguished from the tools used in planing and slotting machines.

Machine, Dynamo Electric. An obsolete expression for DYNAMOS (*q.v.*)

——, **Electrical.** A term used in physics denoting a piece of apparatus for the production of charges of electricity. They include FRICTIONAL MACHINES and INFLUENCE MACHINES, such as those of HOLTZ, VOSS, and WIMSHURST (*q.v.*)

——, **Induction** (*Elect.*) *See* INDUCTION MACHINE (HOLTZ, VOSS, and WIMSHURST MACHINES).

Machine Moulding. Many simple forms of castings, when a great number are required, are moulded by machines, which are in some cases almost automatic. Toothed wheels are very conveniently made in this way. The machines are too complex for a brief description.

Machine Paper (*Paper Manufac.*) Paper made by machinery, in contradistinction to paper made by hand. The latter is generally superior in quality.

Machine Points (*Print.*) Guide points employed on the printing machine in order to obtain accurate register.

Machine Riveting (*Eng.*) Closing rivets by the use of some form of press (often hydraulic) instead of by hammering.

Machine Shop (*Eng.*) The part of an engineering works in which the lathes and other machine tools are worked, as distinguished from the erecting and fitting shops.

Machine Tools (*Eng.*) A general term for machines used in engineering and allied work. *e.g.* PLANING, SLOTTING, SHAPING, MILLING MACHINES, *etc.*

Machining (*Eng., Carp., etc.*) A general term for processes carried out by machine tools, *e.g.* planing, shaping, and milling in metal work, and planing, grooving, and beading in woodwork.

Mackerel Sky (*Meteorol.*) A form of cloud resulting from the breaking up of cirrus cloud, composed of small roundish cloud masses.

Mackle, Mackled (*Print.*) A term implying that the type has dragged on the paper whilst the sheet was being printed, thus giving a kind of double impression.

Macle (*Min.*) A term sometimes used to signify a twin crystal of the contact type.

Maclura (*Botany*). The "bow wood" of the United States belongs to the *Moraceæ*. Its wood is used, and the leaves form food for silkworms.

Macrodiagonal (*Min.*) The longer of the two horizontal axes in the ORTHORHOMBIC SYSTEM.

Macrodome (*Min.*) A crystal form of the orthorhombic system. It is a prism whose axis is the MACRODIAGONAL (*q.v.*)

Macropinakoid (*Min.*) A two faced form of the orthorhombic system. The faces are normal to the macrodiagonal.

Madder. This is the root of ***Rubia tinctorum***, ***R. peregrina***, and ***R. mungista*** (order, ***Rubiaceæ***), a plant growing wild in many parts of Europe and Asia. The plant was at one time extensively cultivated, as the root yields a splendid red dye. It is probably the oldest vegetable red known, and has been detected in Egyptian mummy wrappings. Since the discovery of artificial alizarin, however, madder has, like many other natural dyes, practically fallen into disuse. *See* ALIZARIN *and* DYES AND DYEING.

Made Ground (*Hygiene*). A model byelaw of the Local Government Board prohibits the erection of a new building "upon any site which shall have been filled up with any material impregnated with any animal or vegetable matter, or upon which any such matter may have been deposited, unless and until such matter shall have been properly removed, by excavation or otherwise, from such site." Free exposure for years is necessary for the purification of such soil, and even then it makes an unhealthy site. Any dwelling built upon it should have an air proof basement of concrete or some impermeable material.

Maestoso (*Music*). Majestically: with dignity.

Magellanic Clouds (*Astron.*) Two cloudy oval masses of light visible in the Southern Hemisphere, called NUBECULA MAJOR AND MINOR.

Magenta. Magenta is a red dye, and was so named because it was discovered by Perkin in the year in which the Battle of Magenta was fought (1859). It is also called ANILINE RED and FUCHSINE. It is still employed to some extent as a dye, and also as a pigment in the form of a lake. *See* LAKES *and* DYES AND DYEING.

—— (*Chem.*) *See* FUCHSINE.

Maggiore (*Music*). Major, used sometimes when a piece goes from the minor key to the tonic major, *i.e.* the major key of the same note, as C minor, C major.

Magic Lantern. The colloquial term for the OPTICAL LANTERN (*q.v.*)

Magilp, Magilph (*Paint.*) A mixture of linseed oil and mastic varnish used by artists as a vehicle for pigments.

Magistral (*Chem.*) A product obtained by roasting copper pyrites (*q.v.*) in such a way as to convert the copper and iron into sulphates, and grinding the product to powder. It is used in the extraction of silver from its ores in Mexico by an amalgamation process.

Magma (*Geol.*) The molten mass from which the eruptive rocks of primary origin have subsequently consolidated.

Magnesia (*Chem.*) A common name for magnesium oxide. *See* MAGNESIUM COMPOUNDS.

Magnesia Mixture (*Chem.*) A solution used in the detection and estimation of phosphoric acid or phosphates. It is prepared as follows: 100 grams of crystallised magnesium chloride, 140 grams of ammonium chloride, and 200 cubic cm. of ammonia are made into a solution, and water added to bring the whole up to 1300 cc. The magnesium chloride can be made by precipitating a suitable quantity of the sulphate exactly with barium chloride, filtering, washing, and using the solution.

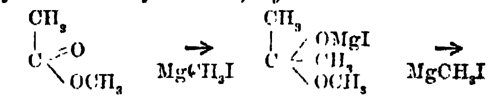
Magnesian Limestone (*Geol.*) A stratigraphical name for a magnesio-calcareous rock which forms a conspicuous horizon near the top of the Dyas, Lower New Red, or "Permian" series of rocks in the north, and especially in the north-east, of England. It was formed in the sea during a temporary return to normal geographical conditions, and in the middle of a lengthy episode during which an arid climate and continental conditions prevailed throughout what is now Western Europe. These finally changed for the better when the Rhætic rocks were formed. The Magnesian Limestone has undergone much reconstruction, and now presents, in consequence, many remarkable structural characteristics.

Magnesite (*Min.*) Magnesium Carbonate, $MgCO_3$. Magnesia = 47·6, carbon dioxide = 52·4 per cent. Rhombohedral; usually not crystallised. White, yellowish, or brown. It is used in the manufacture of Epsom Salts. From Moravia, Styria, Silesia, Norway, the United States, etc.

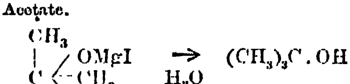
Magnesium, Mg (*Chem.*) Atomic weight, 24. A silvery white metal; melts at 633°; boils about 1100°. In dry air it is not oxidised, but in moist air becomes coated with a film of oxide. When heated in air or oxygen it burns with a very bright flame, rich in the violet and ultra violet light rays. In air the product of combustion is a mixture of the oxide and nitride of the metal. On account of the brightness of the magnesium light the metal is used in making signal lights and in pyrotechny; on account of the brightness and richness in violet and ultra violet rays the metal is used in photography, *e.g.* a good flashlight is obtained by burning a mixture of aluminium powder (12 parts), magnesium powder (13·5 parts), red phosphorus (16 parts), and saltpetre (73 parts) in a celluloid tube. The mixture must be made with a feather. On account of the great heat of formation of its oxide (143,500 cal.) magnesium is able to displace many other elements from their oxides when heated with these oxides, *e.g.* silicon, boron, carbon, etc. It is not attacked by pure water, but solutions of many salts attack it, *e.g.* solutions of potassium chloride and magnesium chloride, yielding magnesium hydroxide and hydrogen. Heated in steam it burns brightly, forming the oxide and liberating hydrogen. Dilute hydrochloric and sulphuric acids dissolve it with formation of the corresponding salt and hydrogen; dilute nitric acid also dissolves it, forming the nitrate, and evolving nitric oxide, nitrous oxide, nitrogen, and hydrogen. Magnesium also precipitates a number of metals from solutions of their salts, *e.g.* copper and iron. It occurs as sulphate in many mineral springs; in sea water; as magnesite, $MgCO_3$; dolomite, $(Mg.Ca)CO_3$; as silicate in many important minerals, *e.g.* asbestos, $(Mg.Ca)SiO_3$; meerschaum, $H_4Mg_2Si_3O_{10}$; and in the Stassfurt salt deposits as carnallite, $KCl.MgCl_2 6H_2O$; kieserite, $MgSO_4H_2O$; and other compounds. Magnesium is obtained (1) by electrolysis of fused carnallite, using a carbon anode and an iron kathode; (2) by heating together carnallite, fluorspar, and sodium to redness in a closed crucible; in this case the metal is purified by distillation.

Magnesium Compounds (*Chem.*) MAGNESIUM OXIDE, MgO: A light white powder; only melts at the temperature of the electric furnace, and on account of its refractory nature is used for lining crucibles and furnaces which are to be used at very high temperatures. Very slightly soluble in water (1 part in 172,000 parts water at 18°); yet when moistened it turns red litmus blue. Used in medicine as a purgative and an antidote in alkaloidal poisoning. It is obtained by heating the carbonate. The

Hydroxide, $Mg(OH)_2$, is a light white powder nearly insoluble in water, but readily soluble in solutions of ammonium salts. Readily gives the oxide on heating. It is obtained by adding a solution of caustic soda to a solution of a magnesium salt. Both oxide and hydroxide readily dissolve in most dilute acids. **Magnesium Nitride**, Mg_3N_2: A yellowish powder obtained by heating the metal in nitrogen or ammonia. It is readily decomposed by steam, $Mg_3N_2+6H_2O=3Mg(OH)_2+2NH_3$. The action of nitrogen on magnesium was used by Ramsay in preparing argon from the air. **Magnesium Chloride**, $MgCl_2$: A white crystalline solid, deliquescent, very soluble in water; it crystallises from a strong solution as $MgCl_2 6H_2O$, but on heating these crystals they lose hydrochloric acid and form the oxide. It forms double salts with the alkali metals, *e.g.* Carnallite, and a similar compound with ammonium chloride in place of potassium chloride. It is obtained by heating Carnallite at 175°, when most of the potassium chloride separates. On cooling, the rest of the potassium chloride separates as carnallite, and the mother liquor contains only magnesium chloride. In the laboratory the carbonate is dissolved in hydrochloric acid, ammonium chloride added to form the double salt, the solution evaporated, and the crystals heated to drive off ammonium chloride. It is used in "dressing" cotton goods. **Magnesium Sulphate**, $MgSO_4$: A white solid, decomposed about 360° into the oxide, sulphur dioxide, and oxygen. It is usually met with as the crystalline hydrate, $MgSO_4 7H_2O$; commonly called **Epsom Salts**: Fine needle shaped crystals; loses $6H_2O$ at 150°, and becomes anhydrous at 200°; very soluble in water. Epsom salts are prepared by allowing Kieserite (*see* Magnesium) to stand in contact with water till it forms $MgSO_4 7H_2O$, and this is purified by crystallisation. It can also be prepared by the action of sulphuric acid on magnesite or on dolomite; in the latter case most of the calcium sulphate remains undissolved, and the magnesium sulphate can be purified by crystallisation. A number of double salts like $K_2SO_4 MgSO_4 6H_2O$ are known. Epsom salts is used in medicine as a purgative, its action depending mainly on osmosis, water being attracted into the intestine. **Magnesium Carbonate**, $MgCO_3$: A white crystalline solid isodimorphous with calcium carbonate; that is, one form crystallises like calcspar, and the other form like arragonite. It occurs naturally as magnesite, and can be prepared by the action of a solution of the chloride on calcium carbonate or by suspending the basic carbonate in water and passing carbon dioxide through the suspension. It is very slightly soluble in water, but more soluble in water containing carbonic acid. A solution prepared by passing carbon dioxide under a pressure of 3 atmospheres into the basic carbonate is used in medicine under the name "fluid magnesia." The **Magnesia Alba** used in medicine is a basic carbonate of the composition $Mg(OH)_2 3MgCO_3$, with a variable quantity of water. It is obtained by mixing solutions of sodium carbonate and magnesium sulphate (*a*) in the cold, and then heating to boiling for the light form; (*b*) at the boiling temperature for the heavy form. Both the normal and basic carbonates are easily decomposed by heat, giving the oxide and carbon dioxide (and water from the basic carbonate). **Magnesium Ammonium Phosphate**, $MgNH_4PO_4$: Small crystals sparingly soluble in water, nearly insoluble in dilute ammonia. It is the form in which magnesium is detected and estimated. On heating, it forms **Magnesium Pyrophosphate**, $2MgNH_4PO_4 = Mg_2P_2O_7 + 2NH_3 + H_2O$. It occurs as a urinary calculus. It is prepared by adding to a solution of magnesium sulphate solutions of ammonium chloride, ammonia, and sodium phosphate in the order given. **Magnesium Sulphide**, MgS: A yellowish brown solid obtained by heating sulphur and magnesium together; it is decomposed by water: $MgS + 2H_2O = Mg(OH)_2 + H_2S$. Magnesium unites with alkyl iodides and bromides in presence of dry ether to form magnesium alkyl halogen compounds, *e.g.* $Mg\begin{matrix}\diagup CH_3\\ \diagdown I\end{matrix}$ and $Mg\begin{matrix}\diagup C_2H_5\\ \diagdown Br\end{matrix}$. These compounds are very important synthetic reagents in organic chemistry. They are decomposed by water, giving the corresponding paraffin, $Mg\begin{matrix}\diagup CH_3\\ \diagdown Br\end{matrix} + HOH = Mg\begin{matrix}\diagup OH\\ \diagdown Br\end{matrix} + CH_4$. With esters of monobasic fatty acids (except formic), acid chlorides, acid anhydrides, and ketones they yield tertiary alcohols; with the esters of formic acid they yield secondary alcohols; *e.g.*

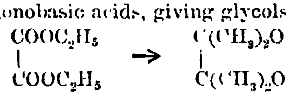


Methyl Acetate.



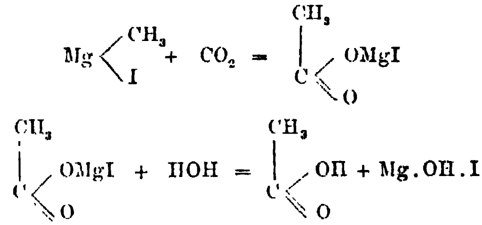
Trimethyl Carbinol.

Esters of dibasic acids react in a similar way to esters of monobasic acids, giving glycols,

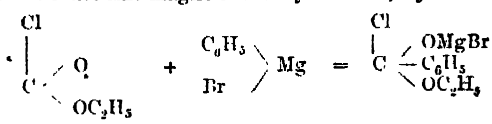


Tetramethyl Glycol (Pinacone).

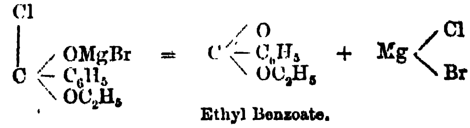
With aldehydes secondary alcohols are obtained. Acids can be synthesised by passing carbon dioxide into an ethereal solution of a magnesium alkyl haloid, and decomposing the precipitated addition product by dilute sulphuric acid at 0°—



For the action on nitriles, *see under* Ketones. Magnesium also replaces the halogen in halogen benzene derivatives, forming compounds like C_6H_5MgBr, and these react like magnesium alkyl haloids, *e.g.*



Ethyl Chlorocarbonate.



Ethyl Benzoate.

Magnesium Light (*Photo.*) An artificial light produced by burning magnesium powder or ribbon; used for photographing interiors of buildings, large groups at night, etc.

Magnet. A NATURAL MAGNET is a piece of a mineral termed MAGNETITE or MAGNETIC OXIDE OF IRON. It possesses the following properties: (1) It attracts small pieces of iron to itself when brought near them. (2) It either repels or attracts a similar magnet, according to the relative positions in which the two are placed with regard to each other. (3) If suspended so that it can turn freely, it sets itself so that two definite points within it lie along a definite direction relative to the earth; this direction is a line pointing approximately north and south. These two points in the magnet are termed its POLES; the line joining them is called the AXIS OF THE MAGNET or MAGNETIC AXIS. An ARTIFICIAL MAGNET is a piece of iron or steel which has acquired properties similar to those of the natural magnet; if it retain these properties it is termed a PERMANENT MAGNET. The MAGNETISM (that which confers on the metal the properties of a magnet) may be supposed to be concentrated at the region of the poles; the amount of such magnetism is termed the STRENGTH OF THE POLE. A UNIT POLE is one which, when placed at 1 cm. from a similar and equal pole, and separated from it by air or some other NON-MAGNETIC material (*q.v.*), repels it with a force of 1 dyne. The pole which tends to turn to the north when the magnet is suspended is termed the POSITIVE or NORTH SEEKING POLE; the other, the NEGATIVE or SOUTH SEEKING POLE. Many of the effects due to a magnet depend upon its MAGNETIC MOMENT or MOMENT OF THE MAGNET, which is the product of the strength of one pole and the length of the axis or line joining the two poles. A magnet may be formed by placing a piece of iron or steel in contact with or in the neighbourhood of another magnet, or by causing an electric current to flow through a wire coiled round the piece of iron. A piece of iron magnetised by a current in the latter way is termed an ELECTRO MAGNET. If the iron be soft, it loses the greater part of its magnetism when the magnetising influence is withdrawn; hard iron or steel retains its magnetism to a great extent, depending largely upon its hardness, and forms a permanent magnet. The main uses of permanent magnets are: (1) As the indicating part of the magnetic compass. (2) As the suspended portion of a large class of galvanometers (*q.v.*) (3) As the field magnets in magneto-electric machines; and (4) for various experimental purposes. Electro-magnets form an essential portion of most electrical appliances and machinery, *e.g.* dynamos, motors, telephones, electric bells, etc.

Magnet Core (*Elect.*) A piece (or number of pieces) of soft iron placed inside a coil or solenoid, and forming with the latter an ELECTRO MAGNET.

——, Diurnal Variation of (*Meteorol., etc.*) It is found that the magnetic needle normally oscillates through a small angle once daily over the mean magnetic meridian. This is called the DIURNAL VARIATION. The angle is greater in summer than in winter.

Magnet Filament, Solenoidal (*Elect.*) A linear magnet or arrangement of magnets having no free magnetism except at the two ends of the line; the external action of the magnet is entirely due to the magnetism at these two points. Such an arrangement is purely theoretical, and is conceived for the purpose of mathematical investigation only.

Magnet, Moment of (*Elect.*) *See* MAGNET.

——, Natural. *See* MAGNET, LODESTONE, and MAGNETITE.

——, Permanent (*Elect.*) *See* MAGNET.

——, Secular Variation of (*Meteorol.*) The progressive alteration of the angle between the magnetic and true meridians at a place. In London it is about 8·5′ annually.

Magnetic Axis (*Elect.*) The axis of a magnet is the line joining the two poles. *See also* MAGNET.

Magnetic Battery (*Elect.*) An expression, now obsolete, for a magnet built up of a number of elements, each element being a separate magnet of suitable form.

Magnetic Bearing (*Surveying, etc.*) The angle between the direction of the compass and that of a line drawn from the observer to a point under observation.

Magnetic Circuit (*Elect.*) Consider a ring of soft iron on which are wound a number of turns of insulated wire. If a current be passed through this wire a MAGNETISING FORCE is set up inside the turns (or helix), which causes a number of lines of force to pass through the iron, each line being a closed curve. The whole system constitutes a MAGNETIC CIRCUIT, having the following analogies to the electric circuit: (1) The FLUX, or total number of lines, corresponds to the electric current. (2) The amount of the flux is directly proportionate to a quantity termed the MAGNETO-MOTIVE FORCE. This is equal to $4\pi NC$, where N is the total number of turns of wire and C the current in absolute units. The magneto-motive force may be defined as the amount of work done in moving a unit magnetic pole once round the circuit, if the iron were absent. (3) The flux is inversely proportional to a quantity termed the RELUCTANCE of the circuit, or its "resistance to the magnetic lines of force." This resistance is proportional to the length of path of the lines of force through the iron, and inversely proportional to the area of the cross section and to the "conductivity for the lines of force" or PERMEABILITY. Let l be the length of the path, a the cross section of the iron, and μ the PERMEABILITY. Then the RELUCTANCE is given by the equation

$$\text{Reluctance} = \frac{l}{a\mu}$$

If a magnetic circuit be composed of different materials, the total Reluctance is the sum of the Reluctances of the separate parts; *e.g.* if there be three different materials of lengths l_1, l_2, l_3, cross section a_1, a_2, a_3, and Permeability μ_1, μ_2, μ_3, the total Reluctance is

$$\frac{l_1}{a_1\mu_1} + \frac{l_2}{a_2\mu_2} + \frac{l_3}{a_3\mu_3}$$

If a part of the path of the lines of force be in the air the Permeability of that part is unity. It is now possible to state the law of the magnetic circuit in a form analogous to the equation expressing the relation of the electric current to the electromotive force and resistance. *See* OHM'S LAW.

$$\text{Flux} = \frac{\text{Magneto-motive Force.}}{\text{Reluctance.}}$$

Magnetic Conductivity (*Elect.*) *See* PERMEABILITY.

Magnetic Control (*Elect.*) (1) The utilisation of the properties of a magnet in order to cause some freely suspended object to set itself in a definite direction, *e.g.* a small magnet is fixed rigidly to the needle of an ELECTROMETER (*q.v.*) (2) In galvanometers containing a suspended magnet the latter may be caused to set itself in a definite direction, independent of the Earth's field, by means of a permanent magnet fixed above the instrument; the directive force on the suspended magnet may also be varied in amount by raising and lowering the controlling magnet.

Magnetic Current (*Elect.*) The rate of change of MAGNETIC FLUX or number of lines of force passing through any surface.

Magnetic Curves (*Elect.*) Curves showing the direction of the lines of force from a magnet, or, more exactly, their projection upon a flat surface, such as a sheet of paper.

Magnetic Cycle (*Elect.*) A complete series of changes in the magnetic condition of a body, such that at the end of the series the body has returned to its original magnetic state.

Magnetic Declination (*Elect.*) See DECLINATION MAGNETIC.

Magnetic Deviation (*Elect.*) *See* DEVIATION, MAGNETIC.

Magnetic Dip (*Elect.*) *See* DIP.

Magnetic Elements (*Elect.*) The three quantities necessary in order to describe completely the magnetism at any given place; they are (1) DECLINATION; (2) DIP; (3) INTENSITY of the magnetic force.

Magnetic Equator (*Elect.*) A line running round the Earth, at any point of which the DIP (*q.v.*) is zero. It is, roughly, midway between the poles.

Magnetic Fatigue (*Elect.*) After iron has been subjected to a large number of changes in its magnetic state, the waste of energy due to HYSTERESIS (*q.v.*) increases. This increase is termed MAGNETIC FATIGUE.

Magnetic Field (*Elect.*) A space through which magnetic lines of force run, and in which therefore a force is exerted on any magnetic pole which may be placed there. Magnetic fields may be (1) Natural or due to the Earth's Magnetism. (2) Produced by the vicinity of magnets. (3) Due to the action of currents.

Magnetic Flux (*Elect.*) The number of magnetic lines of force (*q.v.*) passing through any given area, circuit, etc.

Magnetic Flux Density (*Elect.*) The number of lines of force passing through unit area, situated normally to the lines.

Magnetic Force. The magnetic force at any point is the mechanical force, in dynes, exerted on a UNIT MAGNETIC POLE (*see* MAGNET) placed at the point. It is also equal to the number of LINES OF FORCE crossing unit area surrounding the point. *See* LINES OF FORCE.

Magnetic Hysteresis (*Elect.*) *See* HYSTERESIS.

Magnetic Inclination (*Elect.*) *See* INCLINATION, ANGLE OF.

Magnetic Induction (*Elect.*) (1) The production of magnetic properties in soft iron, etc., when placed in a magnetic field. (2) The magnetic flux density (*q.v.*) in any material placed in a magnetic field. If H denote the strength of this field, I the intensity of magnetisation (*q.v.*) of the material, and B the magnetic induction, then $B = H + 4\pi I$.

Magnetic Lag (*Elect.*) The tendency of the induced magnetism in iron, etc., to lag behind the magnetising force to which it is due. *See also* HYSTERESIS.

Magnetic Leakage (*Elect.*) The passage of lines of force through a space in which they do not produce a useful effect; *e.g.* the passage of lines through the air from one pole piece of a dynamo to another instead of passing through the armature.

Magnetic Meridian (*Elect.*) An imaginary plane passing through the ZENITH (*q.v.*) and through the magnetic north and south points. The axis of a suspended compass needle when at rest lies in this plane.

Magnetic Moment (*Elect.*) The product of the strength of one pole of a magnet and the distance between the poles. *See also* MAGNET.

Magnetic Needle (*Elect.*) A small magnetised rod or needle of steel so suspended or pivoted that it is able to revolve freely about its middle point. The direction in which it comes to rest is that of the magnetic north and south poles, provided no disturbing magnetic influence is near enough to cause it to deviate from its normal direction.

Magnetic North (*Elect.*) The direction in which a magnetic needle points when perfectly free to turn.

Magnetic Observatory (*Elect.*) An observatory furnished with the necessary instruments for measuring the magnetic declination, inclination, intensity, etc. (*q.v.*), and for recording the variations in these quantities.

Magnetic Permeability. *See* PERMEABILITY.

Magnetic Permeance (*Elect.*) PERMEABILITY (*q.v.*)

Magnetic Poles (*Elect.*) A magnet whose length is considerable behaves as if its magnetism were situate almost entirely at two points at or near its ends; these points are termed the POLES. The condition is most nearly fulfilled by the magnets introduced by Searle, which consist of a thin steel wire having a hardened steel sphere at each end; the poles are almost exactly at the centres of these spheres. *See also* MAGNET.

Magnetic Potential (*Elect.*) The magnetic potential at a point is the work which must be done on a unit pole in order to bring it up to that point from an infinite distance, or from a point where the magnetic potential is zero. *See also* POTENTIAL.

Magnetic Reluctance (*Elect.*) A quantity which may be described as the resistance offered to the passage of lines of magnetic force through any material. It is proportional to the length of the material through which the lines run, and inversely proportional to the area of the cross section and to the Permeability (*q.v.*) *See also* MAGNETIC CIRCUIT

Magnetic Remanence (*Elect.*) *See* REMANENCE.

Magnetic Retentivity (*Elect.*) *See* RETENTIVITY.

Magnetic Sands (*Min.*) *See* ILMENITE.

Magnetic Saturation (*Elect.*) *See* SATURATION, MAGNETIC.

Magnetic Shell. A thin sheet of material, one surface of which is magnetised positively, the other negatively. It may be imagined to be built up of a great number of small magnets, each of length equal to the thickness of the sheet, placed side by side with all their like poles pointing in the same direction. The STRENGTH OF A SHELL is equal to its Magnetic Moment per unit area, or, what is the same thing, its Intensity of Magnetisation (*q.v.*) multiplied by the thickness of the shell. The chief importance of a magnetic shell (which is a purely theoretical conception) is that it produces the same magnetic field as a closed circuit of the same shape as the boundary of the shell, and which carries a current equal to the strength of the shell.

Magnetic Storms (*Meteorol.*) Abnormal variations in the earth's magnetic condition which affect the compass needle.

Magnetic Susceptibility (*Elect.*) *See* SUSCEPTIBILITY.

Magneting (*Eng.*) The separation of particles of iron from those of brass, copper, etc., when filings or borings are to be smelted.

Magnetisation, Intensity of (*Elect.*) *See* INTENSITY OF MAGNETISATION.

Magnetism. (1) The science dealing with the properties of magnets and magnetic fields. (2) The state or condition giving rise to the properties of a magnet. A magnetic field is produced whenever electricity is set in motion. By causing the current to flow in a circuit of suitable form, the properties of a magnet may be reproduced. Ampère deduced that all magnetism is due to electric currents flowing in closed circuits of small dimensions, which are present in the matter under observation. A later modification of this theory points to the movement of IONS (*q.v.*) in closed paths as being equivalent to the currents of Ampère's hypothesis.

Magnetite (*Min.*) A sesquioxide and protoxide of iron, $Fe_2O_3 . FeO$. Iron = 72·5, oxygen = 27·5 per cent. Cubic, commonly occurring in octahedra, often embedded in slaty rocks; also massive. Colour and streak black. Strongly magnetic. It is a very valuable ore of iron. Of wide distribution, but sufficiently plentiful to mine in Norway, Sweden, Lapland, and Siberia.

Magneto Electric Machine (*Elect.*) A term now applied to a small dynamo having permanent field magnets. *See also* DYNAMO.

Magnetograph (*Elect.*) A recording instrument for registering variations in the magnetic elements (*q.v.*)

Magneto Ignition (*Motor Cars, etc.*) The use of a magneto electric machine (*q.v.*) for the production of the spark required for the ignition (*q.v.*) in gas and petrol engines.

Magneto Motive Force (*Elect.*) *See* MAGNETIC CIRCUIT.

Magnification (*Optics*). The apparent increase in the size of an object when viewed through (or projected by) some optical system.

Magnifying Power (*Optics*). The ratio between the angle subtended at the eye by the image of an object viewed through an optical system, and the corresponding angle when viewed by the eye alone.

Magnitudes, Stellar (*Astron.*) Stars appear of different brightness; that is, their magnitudes are different. The brightest stars are of the first magnitude. The LIGHT RATIO (*q.v.*) between one magnitude and the next is 2·512.

Mahl Stick (*Paint.*). *See* MAULSTICK.

Mahogany. *See* WOODS.

Mail (*Armour*). A generic term for all kinds of metal armour, formed of rings, chain, or scale. Such armour was used by most Northern nations, as well as by others, from the earliest times until the fourteenth century, when it was superseded by plate armour. *See* ARMOUR.

—— *or* **Maille** (*Silk Manufac.*) A small oval shaped eyelet through which warp thread passes in figured harness. Made of glass for organzine and fine warps, and of metal for coarse spun and other warps.

Mains (*Elect. Eng.*) The insulated conductors by which the current is led from the generating dynamo to the points where it is required for lighting or power. The conductors consist of copper wires, strips, or rods. The insulating materials which surround the wires are usually covered with some protecting coating, *e.g.* a leaden sheath, and the whole main is generally laid in pipes, troughs, or other forms of conduit.

Mainspring (*Watches and Clocks*). The agent of energy in portable timepieces and small house clocks. A long strip of tempered steel coiled in the barrel, so that in its elastic endeavour to uncoil itself it drives the train of wheels.

Maintaining Power (*Watches and Clocks*). The mechanism which keeps a weight clock, or a fusee watch or clock, going during the time of winding. *See* FUSEE, GOING BARREL.

Maintenance, Cap of. *See* CAP OF MAINTENANCE.

Maize (*Botany, Foods*). Indian corn or maize, *Zea mays* (order, *Gramineæ*), is a most important cereal, not only as a food but also for the varied uses of the leaves, etc. In its nutritive value this resembles oats, containing a large quantity of fat; but its albumen, to be rendered digestible, requires careful cooking. Being deficient in gluten, maize does not make good bread. The grain is liable to be affected by a fungus, which causes in man a disease known as *pellagra*, closely resembling scurvy.

Majolica. A class of pottery the decoration of which is effected by means of white and coloured glazes. Considerable quantities of majolica are produced in England, but its home is Italy, where the productions of Lucca della Robbia and Maestro Georgio in the fifteenth and sixteenth centuries still stand pre-eminent as masterpieces in this special type of ceramics. The wares of the former master are chiefly of a yellow body, covered with an opaque white stanniferous glaze, and further ornamented by the application of coloured glazes. Those of the latter are distinguished by wonderful metallic lustres, which it is practically impossible to produce at the present day.

Major (*Music*). (1) In intervals the term given to the "greater" of those which are alike consonant or alike dissonant, *viz.* seconds, thirds, sixths, and sevenths, the smaller being termed "minor." Major intervals contain one semitone more than minor intervals. (2) Scales and concords which have a major third from the keynote and root respectively

are called "major," those having a minor third being called "minor."

Major Axis. The longest diameter of an ellipse.

Major Tone (*Sound*). The ratio between the frequencies of two notes which respectively are proportional to 9 and 8. It is termed the interval $\frac{9}{8}$ in acoustics.

Make. (1) The amount or number of separate articles produced in some given time. (2) The style or quality of article turned out under given conditions.

Make Even (*Typog.*) This term applies more generally to newspaper work, and implies that the compositor is to make his "take" or portion of copy finish off at the end of a line, unless it be a paragraph ending. This enables the various takes to be closed up without loss of time.

Make Up (*Typog.*) The term is applied (1) to the process of composing type into columns or pages; (2) to the matter when made up; (3) to the articles, etc., selected to form the number or issue of a periodical.

Making Ready (*Typog.*) The preliminary process of printing, consisting of the proper placing of the forme on the press or machine, the registering of pages, and the securing of uniform impression of the type. In printing illustrated works from wood blocks or mechanical engravings it also denotes the several processes of underlaying and overlaying (*q.v.*) required to produce the correct impression and artistic effects the varying subjects demand.

Making Up *or* **Mending Up** (*Foundry*). Repairing broken edges in a mould after the pattern is withdrawn.

Malacca Tin (*Met.*) Tin of good quality from mines in the Straits of Malacca. Also termed STRAITS TIN.

Malachite (*Min.*) A basic cupric carbonate, $2CuO.CO_2.H_2O$. Oxide of copper = 71·8, carbon dioxide = 20, water = 8·2 per cent. Also called Green Carbonate of Copper. *See* AZURITE. Monosymmetric, but rarely crystallised. Usually massive and radiating. Often mammillated. Green in colour. It is used as an ornamental stone. Very valuable as an ore of copper. It is found sparingly in Cornwall, Cumberland, Wigtonshire, Shetland, Cork, and Limerick in the British Isles; more abundantly at Chessy in France, Burra Burra in South Australia, in Siberia, the United States, etc.

Malachite Green (*Chem.*) This name is given to various salts, such as the oxalate, chloride, and zinc double chloride of tetramethyldiamidotriphenylcarbinol, $HO.C\begin{cases}C_6H_4.N(CH_3)_2\\C_6H_4.N(CH_3)_2\\C_6H_5\end{cases}$. The last named compound forms colourless shining leaflets, melting at 132°. Insoluble in water; soluble in alcohol. With acids in the cold it gives colourless solutions; but on warming, salts of the base are formed which have a splendid green colour, and are valuable dyes. On reduction it yields the leuco compound tetramethyldiamidotriphenylmethane. Malachite green is prepared as follows: Benzaldehyde (1 mol.) and dimethylaniline (2 mols.) are heated with hydrochloric acid, giving the leuco compound; the latter is carefully oxidised by lead peroxide and dilute hydrochloric acid. The lead is removed by adding sodium sulphate, and the dye precipitated by adding zinc chloride and salting out.

$$HO.\begin{cases}C_6H_4N(CH_3)_2\\C_6H_4N(CH_3)_2\\C_6H_5\end{cases} \qquad HO.C\begin{cases}C_6H_4N(CH_3)_2\\C_6H_4N(CH_3)_2\\C_6H_5\end{cases}$$

Leuco Base (Colourless). Colour Base (Colourless).

$$C\begin{cases}C_6H_4N(CH_3)_2\\=C_6H_4:N(CH_3)_2\\\qquad\quad|\\\qquad\quad Cl\\C_6H_5\end{cases}$$

Salt of Colour Base (Dye).

—— *See* DYES AND DYEING.

Male and Female (*Eng.*) Two parts forming a pair fitting into each other, such as a bolt and its nut. The former is termed a male screw or male element; the latter, the female screw.

Maleic Acid (*Chem.*), $\begin{matrix}CH.COOH\\ \|\\ CH.COOH\end{matrix}$. White rhombic prisms; melts at 130°; soluble in water and in alcohol. On distillation it yields the anhydride $\begin{matrix}CH.CO\\ \|\\ CH.CO\end{matrix}\!\!>\!O$. Reduced by sodium amalgam or hydriodic acid to succinic acid; oxidised by potassium permanganate to mesotartaric acid. Yields acetylene when a solution of its potassium salt is electrolysed. It is changed to fumaric acid on heating at 200°. Obtained from the anhydride or from malic acid (*q.v.*) directly. The anhydride easily yields the acid on solution in water. Fumaric acid yields the anhydride when heated alone or with PCl_5.

Malic Acid (*Chem.*), $\begin{matrix}CH.OH.COOH\\ |\\ CH_2.COOH\end{matrix}$. A white crystalline solid (needles); melts at 100°; deliquescent; soluble in water and alcohol. On heating it behaves as follows: Quickly distilled, maleic acid passes over and fumaric acid remains behind. Kept for a time at 140° to 150°, fumaric acid is produced. Above this temperature maleic anhydride is formed. Heated with hydriodic acid it gives succinic acid. With sulphuric acid and a phenol it forms coumarines; *e.g.* with resorcin it gives 4-oxycoumarin, $HO.C_6H_4\begin{cases}CH:CH\\ \quad |\\ O-CO\end{cases}$. Malic acid is found in many fruits, etc.; *e.g.* unripe apples, currants, cherries, in rhubarb, the tobacco plant, etc. It is obtained from mountain ash berries by neutralising the juice with milk of lime and boiling till impure calcium malate separates, and this is converted to the acid salt by addition of nitric acid, and the acid salt purified by recrystallisation. From the acid salt, malic acid is obtained by precipitating the calcium as oxalate and crystallising the solution. It can be synthesised from succinic acid (*q.v.*) thus:

$$\begin{matrix}CH_2COOH\\ |\\ CH_2COOH\end{matrix} \xrightarrow{Br_2} \begin{matrix}CHBrCOOH\\ |\\ CH_2COOH\end{matrix} \xrightarrow{AgOH} \begin{matrix}CHOHCOOH\\ |\\ CH_2COOH\end{matrix}.$$

Malic acid contains an asymmetric carbon atom, and is accordingly known in the dextrorotatory, lævorotatory, and inactive forms.

Malleability (*Phys, etc.*) The property possessed by various metals of being beaten out into sheets or otherwise changed in form by hammering, without being fractured in the process.

Malleable Cast Iron. Castings which have been deprived of some part of their carbon, thereby leaving the iron less brittle. Used instead of forgings for some small parts of machines, as malleable castings are cheaper than forgings.

Malleable Iron. Wrought iron; the term is sometimes incorrectly applied to Malleable Cast Iron.

Mallet (*Carp., etc.*) A tool consisting of a heavy head fixed on a handle like that of a hammer. Used for striking chisels, wooden objects which would be injured if struck by a hammer, etc. The head may be a block of wood, an iron casing with a wooden core, which projects at each end of the casing so as to form a striking face, or occasionally some other material, *e.g.* raw hide, which is cut into a strip and rolled up to form a cylinder. A raw hide mallet is very useful for many kinds of work which would be injured by a blow from a wooden mallet.

Malm Rubbers. Soft bricks used for the voussoirs of gauged arches. *See also* BRICKS.

Malonic Acid (*Chem.*), $\begin{matrix}COOH\\|\\CH_2\\|\\COOH\end{matrix}$

White crystalline solid; melts at 32°; readily soluble in water and in alcohol. On heating above its melting point, it decomposes into carbon dioxide and acetic acid, $CH_2\begin{matrix}\diagup COOH\\ \diagdown COOH\end{matrix} = \begin{matrix}CH_3\\|\\COOH\end{matrix} + CO_2.$

It is obtained from monochloracetic acid by evaporating a solution of its potassium salt with potassium cyanide, and hydrolysing the potassium cyanacetate so produced with strong hydrochloric acid: from the product the acid is extracted by ether.

$$\begin{matrix}CH_2Cl\\|\\COOK\end{matrix} \xrightarrow{KCN} \begin{matrix}CH_2CN\\|\\COOK\end{matrix} \xrightarrow{HClAq} \begin{matrix}CH_2COOH\\|\\COOH\end{matrix}$$

The ethyl ester is far more important than the acid itself, on account of the large number of syntheses which can be performed with it. This ester, which boils at 195°, is made from the potassium cyanacetate obtained as above, by acting on it with absolute alcohol and dry hydrogen chloride, pouring into ice-cold water, extracting with ether, drying, and fractionally distilling the dry ether extract. In this ester one of the methylene hydrogens is replaceable by sodium (both hydrogens can be replaced by sodium ethoxide), and the sodium malonic ester readily reacts with halogen derivatives, as follows, *e.g.*

$$\begin{matrix}COOC_2H_5\\|\\CH_2\\ \\COOC_2H_5\end{matrix} \quad Na \quad \begin{matrix}COOC_2H_5\\|\\CHNa\\ \\COOC_2H_5\end{matrix} \quad \xrightarrow{C_2H_5I} \quad \begin{matrix}COOC_2H_5\\|\\CHC_2H_5\\|\\COOC_2H_5\end{matrix}$$

The hydrogen atom of the ethyl malonic ester so obtained can be replaced in a perfectly similar manner. When these alkyl and other malonic ester derivatives are hydrolysed, the resulting dibasic acid readily splits off carbon dioxide on heating, *e.g.*

$$\begin{matrix}COOH\\|\\CHC_2H_5\\|\\COOH\end{matrix} = CO_2 + \begin{matrix}CH_2 . C_2H_5\\|\\COOH\end{matrix}$$

Ethylmalonic Acid. **Butyric Acid.**

$$\begin{matrix}COOH\\|\\C(CH_3)_2\\|\\COOH\end{matrix} = CO_2 + \begin{matrix}CH(CH_3)_2\\|\\COOH\end{matrix}$$

Isobutyric Acid.

Other important examples of the use of ethyl malonate as a synthetic agent are the following: (1) Disodium ethyl malonate with ethylene dibromide yields ethyl trimethylene dicarboxylate.

$$\begin{matrix}CH_2Br\\|\\CH_2Br\end{matrix} + Na_2C(COOC_2H_5)_2 = 2NaBr + \begin{matrix}CH_2\\|\\CH_2\end{matrix}\!\!>C(COOC_2H_5)_2$$

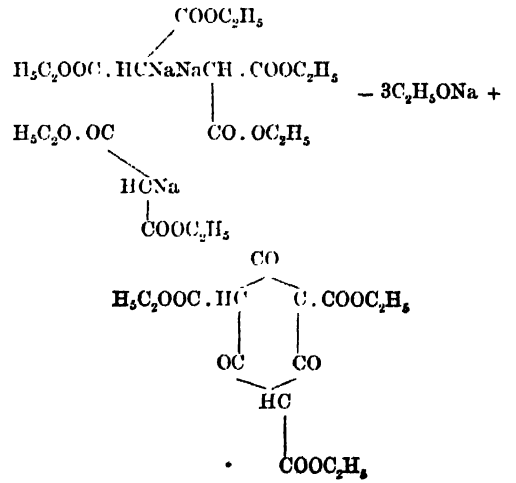
(2) Sodium ethyl malonate with ethyl monobromacetate yields succinic acid.

$$\begin{matrix}COOC_2H_5\\|\\CHNa\\|\\COOC_2H_5\end{matrix} + BrCH_2.COOC_2H_5 = \begin{matrix}COOC_2H_5\\|\\CH.CH_2.COOC_2H_5\\|\\COOC_2H_5\end{matrix} + NaBr.$$

$$\begin{matrix}COOC_2H_5\\|\\CHCH_2COOC_2H_5\\|\\COOC_2H_5\end{matrix} + 3H_2O = \begin{matrix}COOH\\|\\CHCH_2COOH\\|\\COOH\end{matrix} + 3C_2H_5OH$$

$$\begin{matrix}COOH\\|\\CH.CH_2COOH\\|\\COOH\end{matrix} = CO_2 + \begin{matrix}CH_2 . CH_2COOH\\|\\COOH\end{matrix}$$

In this kind of reaction the complexity of the halogen fatty ester, and also of any alkyl group previously introduced into the ethyl malonate, influences the result by "space filling." Thus the reaction occurs readily between sodium ethyl malonate and ethyl monobromacetate, less readily when ethyl α-brompropionate is used, and still less readily when ethyl α-bromisobutyrate is used. With ethyl alkylsodiomalonate and ethyl monobromacetate the ease of the reaction depends on the alkyl group, being easiest with methyl, less easy with ethyl, and not occurring at all with the isopropyl group. (3) Ethyl sodiomalonate, when heated to 120° to 145°, undergoes condensation to ethyl phloroglucin tricarboxylate:



Malt. On germination of the barley grain, *Hordeum vulgare* (order, *Gramineæ*), under suitable conditions of warmth and moisture, the ferment DIASTASE is formed, which changes the starch of the grain into grape sugar and dextrin. The result is malt.

Maltase *or* **Glucase** (*Chem.*) An enzyme (*q.v.*) having the property of hydrolysing the sugar maltose to glucose; it can also to some extent reproduce maltose from glucose. The enzyme is widely spread in both the animal and vegetable kingdoms, *e.g.* in the intestine, pancreas, liver, the blood, and in yeast and the moulds *Aspergilla niger* and *Penicillium glaucum*, in maize, etc.; but the enzyme from all these is probably not quite the same, as yeast maltose hydrolyses α-methyl glucoside, while animal maltase does not. Maltase has the property of resolving amygdalin into a simpler glucoside (the glucoside of benzaldehydecyanhydrin) and one molecule of glucose. Its optimum temperature is 40° to 45°. The enzyme is prepared from a watery extract of maize or from yeast.

Maltose (*Chem.*), $C_{12}H_{22}O_{11} \cdot H_2O$. A white crystalline solid; soluble in water; sparingly soluble in alcohol; dextrorotatory: the fresh solution, + 118·8°; on standing, + 136·8°. Reduces Fehling's solution and ammoniacal silver; gives an osazone (*q.v.*) with phenylhydrazine. Carefully oxidised by bromine water, it yields a monobasic acid, maltobionic acid: oxidised by nitric acid, it gives the dibasic saccharic acid. The enzyme maltase (*q.v.*) hydrolyses it to glucose; so does dilute sulphuric acid on heating. It is fermentable by yeast to alcohol and carbon dioxide. Maltose is prepared from starch by the action of malt; dilute starch paste is treated with malt (or malt extract) at 60° for an hour, boiled and filtered, concentrated, and the syrup extracted with alcohol. After some days the alcoholic solution deposits crystals of maltose.

Mamelières (*Armour*). Circular ornamental plates or bosses fastened on the surcoat of a knight over the breasts. Attached to the mamelières were chains, one of which secured the helmet, the other the sword. They were used from *temp.* Edward I. to Henry V.

Mammals *or* **Mammalia** (*Zool.*) The highest class of animals. The chief characters distinguishing mammals from lower classes are: (1) the close and prolonged connection between the mother and unborn young; (2) the nutrition of the offspring by the mother's milk. There is a small sub-class, however, the MONOTREMATA, including the Duckmole (*Ornithorhyncus*) and certain other animals, which, though possessing mammalian characters, are oviparous, *i.e.* lay eggs. A second sub-class include the MARSUPIALS (kangaroo, etc.); in this the young are born prematurely, and transferred to an external pouch. All other mammals are classed as PLACENTAL MAMMALS, from the presence of the Placenta, the structure uniting the young, before birth, to the mother.

Mancando (*Music*). Weakening the tone.

Manche *or* **Maunche** (*Her.*) A sleeve with long hanging ends, as worn by ladies about the time of Henry I. Used as a charge, but in very conventional form.

Mandelic Acid (*Chem.*) Phenylglycollic acid, $C_6H_5 \cdot {}^*CHOH \cdot COOH$. Contains an asymmetric carbon atom,* and is accordingly known in the dextrorotatory, lævorotatory, and inactive forms. It is a white crystalline solid; the active forms both melt at 133°, and the inactive form melts at 118°; it is soluble in water, alcohol, ether; it is oxidised by dilute nitric acid to benzoylformic acid, then to benzoic acid:

$$\underset{\displaystyle |\atop \displaystyle COOH}{C_6H_5CHOH} \rightarrow \underset{\displaystyle |\atop \displaystyle COOH}{C_6H_5CO} \rightarrow C_6H_5COOH$$

It is reduced by hydriodic acid to phenylacetic acid. The other halogen acids give phenylhalogen acetic acids. It is obtained from amygdalin by warming with hydrochloric acid, and synthetically by acting on benzaldehyde with hydrocyanic acid and hydrolysing the product:

$$C_6H_5CHO \xrightarrow[HCN]{} C_6H_5 \cdot C \begin{cases} H \\ OH \\ CN \end{cases} \xrightarrow[2H_2O]{} C_6H_5C \begin{cases} H \\ OH \\ COOH \end{cases}$$

The active forms can be obtained from the inactive form by making the cinchonine salt of the latter and crystallising. The *d*-mandelic acid salt is the less soluble. Also *Penicillium glaucum* destroys the lævo form, and leaves the dextro form, when it is allowed to grow in inactive ammonium mandelate. When the inactive acid is made into the lævo menthol ester the dextro acid esterifies quicker than the lævo acid, and in this way a separation can be effected.

Mandevile *or* **Mandilion** (*Cost.*) A jerkin or loose cloak, generally without sleeves, worn during the sixteenth and seventeenth centuries.

Mandoline (*Music.*) *See* MUSICAL INSTRUMENTS (STRINGED, II.)

Mandrel *or* **Mandril** (*Eng.*) (1) A general term for a cylindrical object on which work can be mounted for operation in the lathe or elsewhere. (2) The spindle of the headstock of a lathe (*q.v.*)

Maned (*Her.*) When the mane of an animal differs in tincture from the body, it is blazoned maned or, or gu., etc.

Manganates (*Chem.*) *See* MANGANESE COMPOUNDS.

Manganese, Mn (*Chem.*) Atomic weight, 55. A lustrous reddish grey metal; melts in hydrogen at 1240°; stable in air only when pure; when finely divided it attacks water on heating. Easily attacked by acids, giving a manganous salt and liberating hydrogen; even acetic acid attacks it. It precipitates most metals from solutions of their salts, especially the sulphates, on warming. It is not magnetic. For its alloy with iron *see* IRON. Manganese bronze, used in making ships' propellers, is an alloy of copper with ferromanganese. Its principal naturally occurring forms are the dioxide, called PYROLUSITE, MnO_2; BRAUNITE, Mn_2O_3; HAUSMANNITE, Mn_3O_4; MANGANESE SPAR (RHODOCROSITE), $MnCO_3$. The metal may be best obtained by the Goldschmidt process (*q.v.*); also by electrolysis of a saturated solution of manganous chloride, using a kathode of pure mercury and an anode of carbon contained in a porous pot; the product is washed, dried, pressed, and gently heated in a stream of pure and dry hydrogen.

Manganese Bronze (*Met.*) An alloy containing copper, tin, and some FERROMANGANESE (*q.v.*) It forms a very durable alloy, which resists sea water, and is used for propellers of ships.

Manganese Compounds (*Chem.*) Manganese forms three classes of compounds, *viz.* MANGANOUS SALTS, derived from the oxide MnO; MANGANIC SALTS,

derived from the oxide Mn_2O_3; and salts in which manganese occurs in the acid radical, *e.g.* MANGANITES, $R^1_2MnO_3$; MANGANATES, $R^1_2MnO_4$; and PERMANGANATES, R^1MnO_4. MANGANOUS OXIDE, MnO: A green powder; heated in air it gives Mn_3O_4; with acids it yields the manganous salts; obtained by heating any of the higher oxides in a current of hydrogen. If the dioxide is used and the hydrogen is mixed with a little hydrogen chloride, the product is crystalline. Manganous hydroxide, $Mn(OH)_2$: A white solid which rapidly oxidises on exposure to air, forming ultimately Mn_2O_3. It is obtained by mixing air free solutions of manganous chloride and caustic potash in absence of air. MANGANOUS CHLORIDE, $MnCl_2$: A rose coloured deliquescent crystalline solid; vapour density at 1200°—1500° corresponds to formula Mn_2Cl_4; very soluble in water and in alcohol; it gives a green flame in the Bunsen burner. From its aqueous solution it crystallises with $4H_2O$. Obtained by heating the carbonate in a stream of dry hydrogen chloride. From ordinary manganese dioxide (which contains iron) it may be prepared by boiling with hydrochloric acid, precipitating a fraction of the solution by sodium carbonate, filtering and washing the precipitate, and putting it into the remainder of the solution: the manganese carbonate precipitates all the iron as hydroxide; the liquid is now filtered and crystallised. MANGANOUS SULPHATE, $MnSO_4$: A faint rose coloured solid obtained by heating $MnSO_45H_2O$ at 280°; decomposed at a red heat to Mn_3O_4, sulphur dioxide and oxygen. The salt is known crystallised with from 1 to 7 molecules water of crystallisation. Its solution crystallised below 6° gives $MnSO_47H_2O$; isomorphous with $FeSO_47H_2O$; crystallised between 7° and 20° it gives $MnSO_45H_2O$; isomorphous with copper sulphate, $CuSO_45H_2O$, Double salts with the alkali sulphate are known, *e.g.* $K_2SO_4MnSO_46H_2O$ and $K_2SO_4MnSO_44H_2O$. To obtain the salt, manganese dioxide is heated with strong sulphuric acid, water added, filtered, a part precipitated with sodium carbonate, and so on just as under Manganous Chloride. MANGANOUS BORATE, $MnH_4(BO_3)_2$: Is a white powder when freshly precipitated, a brownish powder when dried at 100°; obtained by mixing solutions of manganous sulphate and borax. When added to oils which have the property of absorbing oxygen from the air and slowly forming resins, it greatly accelerates this reaction; hence it is used in the preparation of "drying" oils, etc. TRIMANGANIC TETROXIDE, Mn_3O_4: A reddish brown solid; not changed by heating in air; reduced to MnO by heating in hydrogen, carbon monoxide, or with carbon. Heated with sulphuric acid it gives a mixture of manganous and manganic sulphates; with hydrochloric acid it gives manganous chloride and chlorine; with nitric acid it gives manganous nitrate and manganese dioxide: $Mn_3O_4 + 4HNO_3 = 2Mn(NO_3)_2 + MnO_2 + 2H_2O$. It is obtained by heating any of the other oxides to a high temperature in air, the lower oxide taking up oxygen and the higher oxides losing oxygen; also by heating strongly a mixture of potassium and manganese sulphates: this gives crystals. MANGANIC OXIDE, Mn_2O_3: The natural form, braunite (*q.v.*), forms brownish black crystals; the artificial form is a black powder; strongly heated, it gives Mn_3O_4. With concentrated sulphuric or hydrochloric acids it forms the corresponding manganic salts—sulphate and chloride; but these readily decompose on warming into manganous salts and oxygen and chlorine respectively. It is obtained by allowing manganic sulphate to deliquesce in the air, when it gives the hydrated oxide $Mn_2O_3H_2O$, and this on washing, drying, and gently heating gives the anhydrous oxide; also by heating manganese dioxide in oxygen at 230°. MANGANIC FLOURIDE, MnF_3: A crystalline solid obtained by the action of fluorine on manganous iodide. When heated it gives manganous fluoride and fluorine, so that if this reaction is performed in glass vessels, the glass is violently attacked. MANGANIC CHLORIDE, $MnCl_3$, is only known in solution in cold concentrated hydrochloric acid. MANGANIC SULPHATE, $Mn_2(SO_4)_3$: A dark green solid; decomposes on heating at 180°; deliquescent; easily hydrolysed by water:

$$Mn_2(SO_4)_3 + 4H_2O = (Mn_2O_3.H_2O) + 3H_2SO_4$$

It is obtained by heating a paste of precipitated manganese dioxide and sulphuric acid at 110°, till oxygen is given off; then at 135° to 140°, till it liquefies. This liquid deposits the sulphate which is freed from sulphuric acid by allowing to stand on a porous plate, then washing with concentrated nitric acid, and heating at 150° till the latter is removed. The MANGANESE ALUMS are formed by the union of this sulphate with the alkali sulphates, *e.g.*

$$K_2SO_4 . Mn_2(SO_4)_3 24H_2O$$

MANGANESE DIOXIDE, MnO_2, *also called* Black Oxide of Manganese and Pyrolusite: A black crystalline solid or black finely divided powder. On heating, forms first Mn_2O_3, then Mn_3O_4. It conducts a current of electricity, and on this account, as well as on account of its power to give up oxygen, it is used in the Leclanché cell (*q.v.*) On heating in hydrogen or carbon monoxide, or with carbon, it is reduced to manganous oxide. Heated with sulphuric acid it gives manganous sulphate and oxygen; with hydrochloric acid, manganous chloride and chlorine. It acts as a catalytic agent in the decomposition of hydrogen peroxide and potassium chlorate. It has distinctly acid properties, combining with bases to form manganites. The hydrated oxide formed by precipitation methods is soluble in water, and the solution is acid; also, when precipitation occurs in presence of a base, the precipitate contains some of the base, *i.e.* it contains a manganite. When heated with alkalis manganese dioxide gives manganates (see below). It is prepared by dissolving manganous carbonate (precipitate the chloride with sodium carbonate, filter, and wash) in dilute nitric acid, evaporating to a syrup and heating at 160° to 165° for some hours; washing product with boiling water; drying over sulphuric acid; and finally heating at 180° to 200°. It is formed when manganous sulphate is precipitated by excess of potassium permanganate in presence of acid (nitric); but the precipitate contains potassium—in fact, pure manganese dioxide cannot be prepared by precipitation methods. Besides its use in the Leclanché cell, manganese dioxide is used in colouring pottery brown or violet, in correcting the colour of glass which contains iron, and would be coloured by this, and in the preparation of all other manganese compounds. MANGANESE TRIOXIDE, MnO_3: A reddish, amorphous, deliquescent solid; slowly decomposes at ordinary temperatures; with water it first gives manganic acid, H_2MnO_4, and this decomposes into permanganic acid and manganese dioxide; with alkalis it forms manganates. To obtain it, dry sodium carbonate is placed in a flask standing in cold water; from a tap funnel a solution of potassium permanganate in concentrated sulphuric acid (6 grams in 100 c.c.) is dropped slowly on to the carbonate; the oxide is given off as a pink cloud and condensed in a U-tube filled with broken glass and immersed in ice and salt. The MANGANATES: Salts

of the very unstable manganic acid H_2MnO_4; they are green in colour, and isomorphous with the sulphates; they are all decomposed by acids. Solutions of manganates are only stable in presence of excess of alkali. Potassium manganate may be taken to illustrate their preparation and properties; it is prepared by heating manganese dioxide with caustic potash. If the reaction is performed out of air and in the absence of any oxidising agent, one part of the dioxide is used in oxidising the other part:

$$3MnO_2 + 2KOH = K_2MnO_4 + H_2O + Mn_2O_3$$

$$\left[\begin{array}{c} 2MnO_2 = Mn_2O_3 + O \\ MnO_2 + K_2O.H_2O + O = K_2O.MnO_3 + H_2O \end{array}\right]$$

In presence of an oxidising agent such as potassium chlorate we have:

$$3MnO_2 + 6KOH + KClO_3 = 3K_2MnO_4 + 3H_2O + KCl$$

Potassium manganate is decomposed by water and acids, one part of the manganate being oxidised to permanganate at the expense of the other part:

$$3K_2MnO_4 + 2H_2O = 2KMnO_4 + MnO_2 + 4KOH$$

$$\left[\begin{array}{c} K_2O.MnO_3 = K_2O + MnO_3 = K_2O + MnO_2 + O \\ 2K_2O.MnO_3 + O = K_2O.Mn_2O_7 + K_2O = \\ 2KMnO_4 + K_2O \\ 2K_2O + 2H_2O = 4KOH \end{array}\right]$$

$$5K_2MnO_4 + 4CO_2 + nH_2O = 4KMnO_4 + MnCO_3 + 3K_2CO_3 + nH_2O$$

$$\left[\begin{array}{c} K_2O.MnO_3 + 2CO_2 = K_2CO_3 + MnCO_3 + 2O \\ 4K_2O.MnO_3 + 2O = 2K_2OMn_2O_7 + 2K_2O = \\ 4KMnO_4 + 2K_2O \\ 2K_2O + 2CO_2 = 2K_2CO_3 \end{array}\right]$$

MANGANESE HEPTOXIDE, Mn_2O_7: A dark reddish brown oil; deliquescent; slowly decomposes on standing in air; with water it forms a solution of permanganic acid, $HMnO_4$. It is obtained by dissolving potassium permanganate in concentrated sulphuric acid, which is kept cold by being immersed in a freezing mixture; on cautiously adding water to the green solution, the heptoxide separates. THE PERMANGANATES: The most important of these is potassium permanganate, $KMnO_4$; it forms very dark red prisms with a bluish lustre; moderately soluble in water; on heating it loses oxygen and forms the manganate; it is isomorphous with potassium perchlorate. Its aqueous solution is a powerful oxidising agent; *e.g.* when boiled with toluene it oxidises it to benzoic acid. On account of this oxidising action it is used in medicine as a disinfectant. Its solution with addition of caustic potash is also used as an oxidising agent; in this case the manganate is first formed and then reduced to hydrated manganese dioxide. Such a solution is used, for example, in water analysis in estimating "albuminoid ammonia." Baeyer used the permanganate in presence of sodium carbonate to distinguish between saturated and unsaturated acids. He gives the following table:

INSTANTANEOUSLY OXIDISED.	NOT INSTANTANEOUSLY OXIDISED.
Open Forms.	
Formic acid. The unsaturated acids, *e.g.* fumaric, citraconic, etc., bromacrylic, propiolic, cinnamic, oleic. The last four not quite so rapidly as the others.	Saturated fatty acids except formic, *e.g.* acetic, oxalic, malonic, etc. It is remarkable that the ester of malonic acid is instantaneously oxidised, behaving like ethyl acetoacetate.
Ring Forms.	
The unsaturated hydrogen addition products of the benzenecarboxylic acids, *e.g.* diand tetrahydroterephthalic acids.	Benzene and naphthalenecarboxylic acids. Benzene carboxylic acids saturated with hydrogen, *e.g.* hexahydroterephthalic acid.

Potassium permanganate solution acidified with an excess of sulphuric acid acts as a very powerful oxidising agent:

$$2KMnO_4 + 4H_2SO_4 = 2KHSO_4 + 2MnSO_4 + 3H_2O + 5O$$

On account of this reaction a solution of permanganate of known strength is much used in volumetric analysis. Examples: It oxidises ferrous sulphate to ferric sulphate. We have $2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O$; therefore $2KMnO_4$ gives 5O, which oxidises $10FeSO_4$; it oxidises oxalic acid to carbon dioxide and water. We have

$$C_2H_2O_4 + O = 2CO_2 + H_2O;$$

therefore $2KMnO_4$ gives 5O, which oxidises $5C_2H_2O_4$. Hydrochloric acid heated with potassium permanganate readily gives chlorine:

$$2KMnO_4 + 16HCl = 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$$

For its action on manganous salts see **Manganese Dioxide**; it also oxidises sodium thiosulphate to sodium sulphate. When hydrogen or carbon monoxide is passed through an acidified solution of potassium permanganate, oxygen is evolved. The preparation of this important salt is as follows: caustic potash and potassium chlorate are melted together in an iron crucible, and manganese dioxide added gradually with constant stirring. The green mass obtained on cooling is extracted with water, and a rapid stream of carbon dioxide passed through the liquid, which is then filtered through glass wool, asbestos, or guncotton, and concentrated to crystallisation point. CONDY'S FLUID is a solution of a crude sodium permanganate, obtained by using sodium carbonate in place of caustic potash, and oxidising by air instead of potassium chlorate. The sodium salt is more soluble than the potassium salt, but its reactions are quite similar.

Manganese Spar (*Min.*) A synonym for RHODONITE (*q.v.*)

Manganite (*Min.*) Hydrous sesquioxide of manganese, $Mn_2O_3.H_2O$. Manganese = 62·5, oxygen = 27·5, water = 10 per cent. Orthorhombic, in long striated crystals. Iron black. Often associated with Barytes. It occurs sparingly in Cornwall and Aberdeenshire; more plentifully at Ihlefeld in the Harz; also from several localities in North America.

Manhole (*Eng., etc.*) An opening into a boiler, tank, etc., through which a workman can enter to inspect the interior or to effect repairs. It is closed by a closely fitting watertight door held in position by bolts, and usually so arranged that the internal pressure tends to force it more closely against its seating.

—— (*Hygiene, Build.*) A manhole or intercepting chamber is generally constructed on a foundation of brickwork lined with cement. The main drain should run across the chamber in an open channel formed of half or threequarter channel pipes. Branch drains, in the form of suitably curved channel pipes, should be made to discharge over the main channel, which itself discharges into a syphon trap. This trap should be provided with a raking arm, one end of which opens into the manhole. The chamber should be closed with an airtight cover, and the fresh air admitted by a 6 in. pipe, the manhole end being opposite the entrance of the drain, and the open air end covered by an iron grating and provided with a mica flap. An INSPECTION CHAMBER (*q.v.*) should, if possible, be provided at each point where a change in the direction of the drain is effected.

Manihot (*Botany*). A South American plant of the order *Euphorbiaceæ*. From the tuberous roots are prepared CASSAVA MEAL or BRAZILIAN ARROWROOT and TAPIOCA. One species (*M. glaziovii*) yields CEARA RUBBER.

Manilla Hemp. A native of the Philippine Islands, *Musa textilis* (order, *Musaceæ*), producing valuable fibre for ropes. The fibres are obtained from the stem, previous to flowering.

Manilla Rope. Rope made from the fibres of *Musa hoglodyarum*, a plant growing in Manilla.

Manioc. A synonym for MANIHOT (*q.v.*)

Maniple *or* **Fanon** (*Archæol*). Originally a piece of linen, shaped like a scarf, worn by priests across the left hand or arm, and used by the sacrificing priest perhaps as a handkerchief. On the Bayeux tapestry a maniple is seen in the left hand of Stigand, Archbishop of Canterbury. Subsequently the maniple was richly ornamented.

Manley Stone. *See* BUILDING STONES.

Manna. A saccharine substance used in medicine and obtained as an exudation from the incised stem of a species of ash, *Fraxinus ornus* (order, *Oleaceæ*).

Mannitol *or* **Mannite** (*Chem.*), $CH_2OH.(CHOH)_4.CH_2OH$. A white crystalline solid; sweet taste; melts at 166°; dextrorotatory in solution in presence of borax; soluble in water, sparingly soluble in alcohol. Hydriodic acid reduces it to secondary hexyl iodide, $C_6H_{13}I$. On cautious oxidation with nitric acid it yields the sugar mannose, which is the aldehyde of mannitol; stronger oxidation converts it into saccharic acid. A mixture of concentrated nitric and sulphuric acids gives the hexanitrate. Acetic anhydride gives the hexa-acetate. It occurs in manna (the evaporated sap of species of ash), celery, common syringa, in a common fungus (*Agaricus integer*), and it is obtained from manna by boiling with dilute alcohol, allowing to crystallise, and then purifying the crystals by recrystallisation. It is also obtained by reduction of mannose, lævulose, and mannonic acid. The lævo and inactive forms are known.

Mannonic Acid (*Chem.*), $CH_2OH.(CHOH)_4COOH. = C_6H_{12}O_7$. Only known in the form of its salts. When liberated from its salts it forms the Lactone (*see* LACTONES) $C_6H_{10}O_6$: a white crystalline solid (prisms); melts about 150°; soluble in water; it is known in the dextro, lævo, and inactive forms. The inactive acid can be resolved by making its strychnine salt and crystallising from alcohol when the lævo salt separates first. When *d*-mannonic acid is heated with quinoline and a little water at 140°, it is partly converted into *d*-gluconic acid, the unchanged *d*-mannonic acid being separated by means of its brucine salt. Mannonic acid yields mannose on reduction. It is prepared by oxidation of mannose (*q.v.*), or from gluconic acid by heating with quinoline (*see above*):

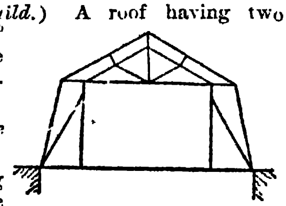
$$\text{Mannonic acid} \underset{\left(\begin{smallmatrix}\text{Heated with}\\ \text{quinoline}\end{smallmatrix}\right)}{\rightleftarrows} \text{Gluconic acid.}$$

Mannose (*Chem.*), $CH_2OH.(CHOH)_4CHO$. Colourless solid; melts at 136°; soluble in water. It is known in the dextro, lævo, and inactive forms. The inactive form can be made to yield the lævo form by fermentation with yeast, when the dextro form is first decomposed, the lævo form remaining. It is sweet; reduces Fehling's solution; yields the same osazone as glucose with phenylhydrazine. On reduction it yields mannitol, and on careful oxidation with bromine it yields mannonic acid. It is obtained from the reserve cellulose (seminine; hence this sugar is sometimes called seminose) of plant seeds by hydrolysis with a dilute acid; also by oxidation of mannitol (*q.v.*) *See also* DEXTROSE *and* SUGARS.

Manometer (*Phys.*) An instrument for measuring fluid pressure; the simplest form consists of a U-tube, one limb being open, the other connected to the vessel containing the fluid whose pressure is to be measured. A suitable liquid (*e.g.* mercury) is placed in the bend of the tube. The difference in level of the liquid in the two limbs enables the required pressure to be calculated. A simple form of AIR MANOMETER is formed by sealing up the free end of a similar U-tube, so as to enclose a convenient volume of air above the mercury in the sealed limb. The pressure is calculated from the amount by which this air is compressed, *i.e.* from Boyle's Law, making allowance for the difference in level of the mercury in the two limbs.

Manometric Flame (*Phys.*) A gas flame used for indicating small variations of gaseous pressure, as in experiments on vibrating columns of air. The changes of pressure are communicated to the gas supplying the flame by means of a flexible diaphragm; the space on one side of this communicates with the gas supply, and that on the other with the air which is in vibration. The variations of pressure cause changes in the size of the flame; these changes are observed by means of a rotating mirror, as they are too rapid to be detected by the unaided eye.

Mansard Roof (*Build.*) A roof having two pitches, generally 60° and 30°, to allow space for a room in the roof. *See also* ROOFS.



MANSARD ROOF.

Mansfield Stone. *See* BUILDING STONES.

Mantle (*Her.*) A long robe worn in the middle ages over the armour, and still used as part of the insignia of knightly orders.

——, **Incandescent.** A cap or cover composed of a meshed fabric containing oxides of certain rare earths; when heated by being placed over a non-luminous flame it becomes incandescent, emitting a brilliant light, somewhat rich in violet rays. The best known form is the WELSBACH MANTLE (*q.v.*)

Mantling (*Her.*) *See* LAMBREQUIN.

Manual (*Music*). The keyboard played by the hands. *See* ORGAN.

Manubrium (*Zool.*) A process (*q.v.*) of the sternum and of the hammerbone or malleus in the ear.

Maple. *See* WOODS.

Map Varnish. The prime requisites for a map varnish are transparency and elasticity, so that the varnish does not hide details, and will not crack if the map is rolled up, nor peel off with atmospheric changes. Any nearly colourless gum may be dissolved in a colourless solvent to prepare these varnishes. Sandarach or mastic, with spirit of wine and Venice turpentine as solvents, form the usual

ingredients. The Venice turpentine increases the elasticity. An excellent recipe is: 72 oz. of finest mastic, 46 of oil of turpentine, 10 of Venice turpentine, 3 of camphor, and 200 of strong spirit of wine (96 per cent.)

Maraschino. A liqueur made from cherry kernels that have been infused in spirit and afterwards distilled.

Marble (*Build.*) *See* BUILDING STONES.

—— (*Geol.*) A term often used to denote any kind of rock other than granite or freestone, which is suitable for decorative building purposes. Marble is, however, strictly speaking, a limestone of pleasing colour and pattern, which takes and retains a good polish. Most of the marbles, and especially those with a saccharoidal structure, were originally limestones of ordinary character, which have undergone recrystallisation. In the process of this reconstruction the various impurities present in the rock have also undergone rearrangement, and thus given rise to some of the varied patterns seen in marble.

Marbled Paper, Marbled Edges (*Bind.*) Marbled paper, *i.e.* paper coloured and veined in imitation of marble, is often used to form the end papers of books. It is also used for the covers of certain styles of half bound books. The edges of books when marbled should match the end papers.

Marble, Imitation. *See* MAREZZO *and* SCAGLIOLA.

——, **Statuary.** The marble chiefly employed for sculpture is of a saccharoidal texture, *i.e.* it resembles in structure loaf sugar. The marbles used most extensively by the ancient Greeks were (1) Parian: a finely grained, durable stone from which some of their finest figures, including the famous Venus de Medici, were formed. (2) Pentelic: a coarser grained stone than Parian; used entirely in the construction of the Parthenon. In modern times the best known and most extensively employed is Carrara, a serviceable and beautiful medium, when pure; but it is not infrequently blemished by black or grey veinings.

Marcasite (*Min.*) A sulphide of iron, FeS_2. Sulphur = 53, iron = 47 per cent. Orthorhombic; often twinned. It is a less stable compound than Iron Pyrites, and is rather paler in colour usually, being a pale brassy colour. It is a much less plentiful mineral than pyrites. Formerly used for ornamental purposes. Of wide distribution, often in altered limestone; also in the chalk.

Marcatissimo (*Music*). Very marked: greatly accented.

Marcato (*Music*). Marked: accented.

Marchioness (*Build.*) A roofing slate measuring 22 by 11 in.

Mares' Grease. A lubricant from the fat of horses slaughtered for hides, etc., in South America. *See* LUBRICANTS.

Marezzo (*Build.*) An imitation marble formed of Keene's cement and various colouring matters, used for panels, pilasters, and columns. The process of manufacture is as follows: threads of manilla grass, floss silk, or other suitable fibres are dipped into a "slip" (*q.v.*) of Keene's cement, coloured to the tint of the veining desired. These are arranged on a sheet of plate glass or other smooth surface to form the markings. Another thin coat of "slip," tinted to the body colour of the marble to be imitated, is now poured on. The threads are then carefully picked out, leaving behind them the veining colours, and dry cement is sprinkled on to absorb superfluous moisture. This preparation forms a surface to which a canvas backing is attached to strengthen it, the whole being further strengthened by a coat of cement to the required thickness. When dry the slab is removed and polished.

Margarine (*Foods*). Manufactured chiefly from beef and mutton fat (a mixture of stearin, margarine, and olein). The beef fat is first finely minced and heated to about 100° F. The water and *débris* sink to the bottom, and the fat is run off as a clear yellow oil, and kept at a temperature of about 86° F. The stearin solidifies and the oleomargarine is separated as a liquid, filtered, pressed, churned up with milk, coloured with annatto, cooled with ice, and is then ready for sale. By the Margarine Act, 1887, it may only be lawfully sold under certain conditions. Every package or parcel of margarine must be marked in capital letters not less than ½ in. long, and no other printed matter shall appear on the wrapper (section 6). All margarine manufactured or imported must be consigned as margarine (section 8). The premises upon which margarine is manufactured must be registered with the local authority (section 9). By the Sale of Food and Drugs Act, 1899, section 8, no margarine must be sold which contains more than 10 per cent. of butter fat. Section 5 extends provisions relating to margarine to margarine cheese.

Margery's Fluid. A solution of copper sulphate used to preserve timber.

Margin (*Build.*) The part of each slate on a roof exposed to the view.

Marigold Window (*Architect.*) *See* ROSE WINDOW.

Marine Boiler (*Eng.*) These are either cylindrical boilers of the type known as the SCOTCH BOILER (*q.v.*) or of the WATER TUBE type, such as the Belleville, Babcock & Wilcox, etc. *See also* BOILERS.

Marine Compass. A form of magnetic compass (*q.v.*) suspended by pivoted rings in such a manner as to remain as horizontal as possible during the motion of a ship. In modern ships the magnetic effects due to the iron in the vessel are corrected by fixing compensating masses of iron in suitable positions.

Marine Denudation (*Geol.*) *See* DENUDATION.

Marine Deposits (*Geol.*) Sediments of various kinds which are left on the floor of the sea. They may be classed as (1) Pelagic Deposits, which have been formed in deep water far from the land; (2) Thalassic Deposits, formed also in clear water, but nearer the shore; and (3) Terrigenous Deposits, which represent materials of mechanical origin left not far from the land, and which have been transported from it by the action of water in motion. The siliceous Radiolarian Ooze is a good example of the first; many Foraminiferal Oozes belong to the second category; while the third embraces the Glauconitic Sands, coral muds, and the various sandy and muddy deposits that are left within a few miles of the shore.

Marine Engine (*Eng.*) Modern marine engines are almost invariably compound engines, with two, three, or sometimes four inverted cylinders, in which the steam is expanded in succession. *See* STEAM ENGINE. The latest development is the use of the STEAM TURBINE, as in the *Queen* (Channel service), *Edward VII.* (Clyde), and certain yachts and torpedo boat destroyers.

Marine Glue. A cement containing rubber, shellac, and oil. It is melted and applied hot to wood and other materials where a watertight joint is required.

Marinoni Machine (*Print.*) *See* TYPOGRAPHY.

Marking Gauge (*Carp., etc.*) A short rod of wood having a steel marking point projecting at right angles near one end; on the rod slides a block forming a guide or "fence," which can be fixed in any required position. Used for marking a single line parallel to and at a given distance from the edge of a piece of wood. *Cf.* MORTICE GAUGE.

Marking Ink. *See* INKS.

Marking Out (*Eng.*) The process of marking on a piece of work the principal lines, centres, and measurements of the finished article.

Mark of Cadency *or* **Difference** (*Her.*) A device adopted to distinguish different members of the same family who bear the same arms. *See* LABEL.

Marks (*Met., Eng.*) The brands, such as B, BB, etc., which denote the quality of metal.

Marks of Reference (*Typog.*) *See* NOTES.

Marl (*Geol.*) In text books marl is generally defined as a "calcareous clay"; in practical geological work the term is almost universally applied to any half-indurated clay, which readily crumbles to small fragments and eventually forms into clay of the ordinary type after exposure to the weather. The marls of the New Red or of the Old Red rock are typical examples. The clay which, mixed with shells and other calcareous matter, forms at the bottom of some lakes, is distinguished as SHELL MARL. *See also* BRICKS.

Marquetry. A method of decoration effected by inlaying with pieces of wood, metal, and other materials of different colours placed in juxtaposition, and arranged to form various patterns. Buhl furniture is an example of this style of decoration.

Mars (*Astron.*) Distance from sun, 141,500,000 miles; diameter, 4,230 miles; periodic time, 687 days; time of rotation, $24\frac{1}{2}$ hours. It has two small satellites (Phobos and Deimos). Periods $7\frac{1}{2}$ hours and $30\frac{1}{4}$ hours respectively.

Marsh Gas (*Chem.*) A common name for METHANE (*q.v.*)

Marsh's Test (*Chem.*) A test for arsenic and antimony depending on the production and behaviour of their compounds with hydrogen. The substance to be tested must be in solution or be soluble; if it is mixed with organic matter, this must be destroyed, for example, by gentle warming with hydrochloric acid and potassium chlorate, and subsequent removal of all traces of chlorine and chlorine oxyacids. A compound like arsenious sulphide must be oxidised to arsenic acid by nitric acid, and excess of the latter removed by evaporation, because the sulphide is insoluble in the reagents employed, while arsenic acid is readily soluble. Zinc or magnesium free from arsenic is placed in a flask fitted with delivery tube and thistle funnel. The delivery tube is attached to a tube of calcium chloride to dry the escaping gases, and the drying tube is attached to a piece of hard glass tubing, narrowed to a jet at the further end. Dilute hydrochloric acid freed from arsenic (this can be done by previously heating the acid with clean strips of copper) is poured down the thistle funnel on to the zinc or magnesium. With zinc, if the action will not begin, a little platinum chloride may be added. The apparatus is now left till the hydrogen which is generated has displaced all air from the apparatus. Now the solution to be tested is poured in, and some of the hydrogen, instead of being set free as such, reduces the arsenic or antimony compound to hydride, AsH_3 or SbH_3, which escapes with the excess of hydrogen. If a fair amount of arsenic or antimony is present, the hydrogen and hydride may be lighted at the tip of the hard glass tube, and a cold porcelain surface held over the flame. The incomplete air supply caused by the porcelain burns the hydrogen of the hydride to water, while most of the arsenic or antimony, if the flame is not large, is deposited on the porcelain. This deposit is soluble in bleaching powder solution if it is arsenic; insoluble if it is antimony. A drop of nitric acid dissolves it in both cases on warming, and silver nitrate added to the solution, followed by very cautious addition of ammonia, gives a reddish brown precipitate with arsenic, but not with antimony. If the amount of arsenic or antimony is small, the hard glass tube is heated, when the hydride is resolved into its elements, and a deposit of arsenic or antimony is obtained: with traces of these elements this process must go on for hours. The deposits can be distinguished by their appearance and by subliming them in a current of air when the arsenic forms crystals of arsenious oxide which can be identified under the microscope, while the antimony gives an amorphous deposit of oxide. This process can be made quantitative by comparing the arsenic deposit with that produced by a known amount of arsenic in a similar apparatus. Several substances interfere with the production of the hydrides, *e.g.* presence of iron, nitrates, nitrites, sulphuretted hydrogen. It is a very delicate test, but opinions vary as to its delicacy; it will detect $\frac{1}{250}$ of a milligram of arsenic, or, according to some, $\frac{1}{1000}$ of a milligram.

Martel de Fer (*Arms*). A hammer headed weapon, being a combination of the mallet and pick, one half of the head being shaped like the ordinary hammer or mallet, the other pointed like a pick. There were two kinds, the long handled and the short handled, the former used chiefly by horsemen. Used during the fourteenth and fifteenth centuries.

Martellato (*Music*). Hammered.

Marten (*Zool.*) A member of the polecat and weasel family (order, *Mustelidæ*). The PINE MARTEN (*Mustela martes*) yields a valuable fur, which is often sold as an inferior sable. The AMERICAN MARTEN (*M. americana*) also has a fur of great value.

Martensite (*Chem., Met.*) *See* IRON.

Martlet (*Her.*) The heraldic swallow, represented without legs and with long wings. It is used as a difference or mark of cadency for the fourth son.

Marver (*Glass Manufac.*) A polished plate of cast or wrought iron placed upon a wooden bench or stool. Used for consolidating and centreing the molten glass upon the blowing iron. *See also* GLASS MANUFACTURE.

Marziale, Alla Marsia (*Music*). In march time: martial.

Mascle (*Her.*) A lozenge, perforated or "voided."

Mascled Armour. A kind of mail armour consisting of lozenge shaped pieces of metal attached to a leathern tunic. Armour of this kind was worn by the Normans, and is depicted on the Bayeux tapestry.

Mask (*Photo.*) An opaque screen, often of black paper, or else of some varnish painted on, used to cut off part of a negative during printing.

—— *or* **Masque** (*Architect.*) An ornament used in cornices and in corbels in English architecture during the thirteenth and fourteenth centuries. In front elevation it is similar to a buckle, and its shadow on the wall resembles the profile of a human face. It is also known as a BUCKLE or NOTCH HEAD.

Masoned (*Her.*) When the dividing lines in the masonry of a building such as a castle or tower are represented, they are described as masoned.

Masonry. The preparation and fitting together of stones in the construction of buildings, walls, etc. Stonework as distinguished from brickwork. *See* ASHLAR *and* RUBBLE.

Mason's Mitre (*Build.*) In mason's work all mitres are worked in the solid; that is to say, the angle is formed from one piece of stone, so that there is no actual joint along the line at which the two mouldings meet.

Mass. Mass usually means the "quantity of matter" in a body. The dynamical measurement of mass is based upon the change in velocity (acceleration) produced in a given time by a given force, which acts on the body. Thus equal masses are those in which equal forces produce equal changes of velocity in equal times.

Mass Action (*Chem.*) If steam is passed over red-hot iron the magnetic oxide of iron and hydrogen are produced; if hydrogen is passed over red-hot magnetic oxide of iron, iron and steam are produced.

$$3Fe + 4H_2O \rightleftarrows Fe_3O_4 + 4H_2$$

At a certain temperature, and with a mixture of iron and magnetic oxide in certain proportions, and a mixture of hydrogen and steam in certain proportions, it is clear that just as much iron will be converted into magnetic oxide as is produced from the magnetic oxide. If now the value of the ratio $\frac{\text{steam}}{\text{hydrogen}}$ is increased by a small amount and again kept constant at its new value, the ratio $\frac{\text{iron}}{\text{magnetic oxide}}$ will be diminished by certain amount, but will again become constant at a smaller value. This kind of reaction is called a mass action, and most chemical actions are of this kind, *e.g.* (1) Reactions like the above with other metals besides hydrogen. (2) Dissociation of a compound AB when the dissociation products A and B are present with unchanged substance AB. (3) Double decomposition occurring in a homogeneous liquid, as in the case of alcohol and acetic acid, which form ethyl acetate and water, and are reproduced from these; or in the case of potassium sulphocyanate and ferric chloride in aqueous solution, which form ferric sulphocyanate and potassium chloride, and are reproduced from these. (4) A soluble salt in solution and a nearly insoluble salt partly exchange acids, as in the case of potassium carbonate and barium sulphate, which form potassium sulphate and barium carbonate, and are reproduced from these. Taking the last case, the following table will show the influence of time and mass of the potassium carbonate. The temperature is 100°, and at the beginning of the reaction one molecular proportion of barium sulphate was present and 500 molecular proportions of water. There are seven separate experiments, and the absolute amount of barium sulphate at the beginning is given in each.

Molecules K_2CO_3	Percentage of $BaSO_4$ decomposed.	Absolute initial amount of $BaSO_4$ in grams.	Time in hours.
1	8·5	1·2251	1
2	36·1	1·4023	109
3	56·9	1·2589	109
4	78·2	1·3068	109
5	96·2	1·3328	113
7·5	98·4	1·2604	112
7·5	97·1	1·3340	163

It is unfortunate that the amounts of barium sulphate were not absolutely the same in each experiment; still, the table is useful. To get an idea of the law of mass action, consider the homogeneous system obtained when one molecular proportion of acetic acid and ethyl alcohol are mixed at the ordinary temperature and left to stand at that constant temperature; ethyl acetate and water are formed, and these begin to reproduce the acid and alcohol, the first reaction gradually becoming slower and the second gradually quicker, until the speed of each is the same; then, as far as the amount of each of the four substances is concerned, there is no further change. We shall express this condition by saying the system is in equilibrium. Let x of a molecular proportion of alcohol be the amount transformed when we have equilibrium, x is evidently in our case a proper fraction. Then we may express the state of affairs by the following equation:

$$C_2H_5OH + CH_3COOH = (1-x)C_2H_5OH + (1-x)CH_3COOH + xCH_3COOC_2H_5 + xH_2O$$

The law of mass action for this case is

$$k(1-x)(1-x) = k'x \cdot x \text{ or } k(1-x)^2 = k'x^2$$

k is a constant called the affinity constant for alcohol and acetic acid, and k' is a similar constant for the ester and water. $(1-x)$ is called the "active mass" of the alcohol and acetic acid, and x the "active mass" of the ester and water. The active mass of a substance is now generally expressed by the number of gram molecules per unit volume of the system; this is called the concentration of the substance. The general equation for a system such as the above, where only one molecule of each substance reacts, is $k, p, q = k'. p', q'$. The general equation for any system which is homogeneous and in equilibrium, and for which the chemical equation is

$$\alpha P + \beta Q + \ldots = \alpha' P' + \beta' Q' + \ldots$$

is $kp^{\alpha}q^{\beta} \ldots = k'p'^{\alpha}q'^{\beta} \ldots$ where $p, q \ldots p', q' \ldots$ are the concentrations (gram molecules per litre) of $P, Q \ldots P', Q' \ldots$ The above formulæ hold for gases as well as liquids; only as the concentration of a gas is directly proportional to its pressure, pressures are usually substituted for concentrations. In all the above cases it is assumed that no other action occurs than that indicated; that is, the products of a reaction are assumed to be without action on the original substances. Cases of heterogeneous systems, such as that between iron, magnetic oxide, steam, and hydrogen, and that between barium sulphate, potassium carbonate, potassium sulphate, and barium carbonate, are treated on the assumption that the active masses (concentrations) of the solids are constant; that is, the iron and magnetic oxide in the first case have each a small and constant vapour pressure, and the barium sulphate and barium carbonate have each a small and constant solubility. Example: Chemical equation,

$$3Fe + 4H_2O \rightleftarrows Fe_3O_4 + 4H_2$$

Applying the general formula, we have $k_1 p^2 q^4 = k' p' q'^4$, where k and k' are the "affinity constants," p and p' are the vapour pressures of the solids, and q and q' the partial pressures of the steam and hydrogen respectively. Hence

$$\left(\frac{q}{q'}\right)^4 = \frac{k'p'}{kp^2} = \text{Constant}$$

$$\therefore \frac{q}{q'} = \text{Constant}$$

Deville found in two experiments:

$$\frac{q}{q'} = \frac{4 \cdot 6}{25 \cdot 8} \text{ and } \frac{q}{q'} = \frac{10 \cdot 1}{57 \cdot 9}$$
$$= 0 \cdot 178 \qquad = 0 \cdot 174$$

The error is well within the limits of experimental error.

Massicot (*Chem.*) *See* LEAD COMPOUNDS.

Mässig (*Music*). The German equivalent for MODERATO (*q.v.*)

Massive (*Min.*) The term applied to the mode of occurrence of a mineral which is found in large masses, as distinguished from crystals, granules, lamellæ, or other forms.

Mast (*Eng.*) Any vertical pole, such as the upright post in certain cranes. In electrical traction the pole carrying the trolley wheel which makes contact with the overhead wire is termed a mast.

Mastaba (*Architect.*) The common form of the ancient Egyptian tomb; its shape is that of a truncated pyramid. They each contained a chamber near the entrance, in which offerings were placed; several secret chambers, known as SERDABS; and an underground chamber, containing the mummy.

Master (*Art*). A term applied to the founder of a "school." One who is eminently skilled in some branch of art.

—— (*Eng.*) A term applied to various tools used either as standards or for the production of other tools to a standard size or pattern, *e.g.* a MASTER TAP (*q.v.*)

Master Clock (*Clocks*). The timepiece controlling and actuating by electricity a series of dial works, or "journeymen," at different points in the circuit. *See* INDICATOR DIAL.

Masterpiece (*Art*). A great and masterly work of art; a work which is superior to any other by the same person.

Master Tap (*Eng.*) A standard tap, used for making the dies used in cutting screw threads.

Master Wheel (*Eng.*) A large wheel, accurately divided, used for correctly dividing out the teeth when cutting gear wheels.

Mastic (*Botany*). A resin from the incised bark of the stem and branches of a Mediterranean tree, *Pistacia lentiscus* (order, *Anacardiaceæ*). Used in medicine and as a varnish.

—— (*Build.*) A cement made of powdered stone or bricks mixed with oil and driers.

Mat, Celtic *or* **Basket** (*Textile Manufac.*) A type of weave in which the warp and weft form small squares. Mats are of three kinds, namely, ordinary (*i.e.* squares of warp and weft equal in size), irregular, and twilled.

Match Boarding (*Carp. and Join.*) Boards each having a tongue worked on one edge and a groove on the other edge, so they may be fitted together. The tongues and grooves are cut by machinery, and the boarding supplied by the timber merchants ready for use. Often termed MATCHING.

Matchbox *or* **Pipe** (*Arms*). A metal tube carried by matchlock men to protect the lighted match with which they fired their weapon from the weather.

Matchlock (*Arms*). One of the early forms of hand gun used during the fifteenth century. It was fired by means of a slow match, which was fixed in a lever on the gun.

Match Plate (*Foundry*). A flat plate to each side of which one half of a pattern is attached; the mould is made in two halves by the two parts of the pattern. In certain classes of work this method saves considerable time.

Mate. An assistant or subordinate who assists a more skilled workman. The term is also used in its ordinary sense for men working together.

Maté (*Botany*). *See* ILEX

Matelasse (*Textile Manufac.*) French term for a type of figured mantle cloth in which the design or pattern may be formed entirely either by the warp or by the weft. In other types, both warp and weft show on the face of the cloth.

Matico (*Botany*). A powerful styptic drug consisting of the dried leaves of the plant *Piper angustifolium* (order, *Piperaceæ*).

Matrix (*Build., etc.*) The cementing material mixed with the aggregate for making concrete.

—— (*Typog.*) The copper mould or "strike" from which type is cast.

—— *or* **Matrice**, *pl.* **Matrices**. In a general sense, the mould or form in which anything is shaped. A die from which impressions in relief are obtained.

Matt (*Dec.*) Having a dull or lustreless appearance; used with reference to colours in distemper which are left unvarnished.

—— *or* **Regulus** (*Met.*) A mass of partly purified metal in some intermediate stage of the smelting process, especially applied to Copper when in the condition of Coarse Metal or Fine Metal. *See* COPPER *and* METALLURGY.

Matter. Matter is defined as (1) that which occupies space; (2) that which possesses inertia. Of the actual nature, constitution, or ultimate structure of matter no exact statements can be made.

—— (*Engrav.*) An implement in the form of a punch used by mezzotint engravers for "matting" or laying a light, *i.e.* darkening the parts of a plate where the lights are too high.

—— (*Typog.*) Set up or composed type.

——, **States of** (*Phys.*) Matter may exist in three different well marked states, as: (1) A SOLID. (2) A LIQUID. (3) A GAS (*q.v.*) Certain other transitional and less marked states are also observable under special conditions.

Matt Gold Size (*Dec.*) A size used in gilding where the surface is required to be dead, *i.e.* without gloss. It is sold ready for mixing with jelly size.

Maulstick (*Paint.*) A light stick about a yard long, held in the left hand and used by painters to steady and support the right hand when painting.

Mauritius Hemp (*Botany*). *See* FURCRÆA.

Maxilla (*Zool.*) (1) In vertebrates, a jawbone; (2) An appendage in the Crayfish and other Crustacea.

Maxima and Minima (*Math., Phys.*) A quantity which varies periodically and continuously (*e.g.* the sine of a constantly increasing angle) attains a certain value, at which it ceases to increase, and commences to diminish. This value is termed a MAXIMUM. After passing through this value, the quantity diminishes until it reaches a certain value, termed a MINIMUM, at which it commences to increase again. In a Sine Curve (*q.v.*) the successive maxima are equal, as are also the successive minima; but this is not necessarily the case.

Maximum and Minimum Thermometer. A form of thermometer possessing some device for recording the highest or lowest temperature registered by the instrument during some given observation. In many forms the recording device consists of an index, generally some small body which is readily pushed along the bore in one direction by the surface of the liquid, but which is left behind when the surface moves in the opposite direction. In RUTHERFORD'S form the maximum thermometer contains mercury, the surface of which is in contact with an index consisting of a short rod of iron or steel placed *outside* the mercury. The whole tube is horizontal, and the index is pushed along when the temperature rises, and is left behind when the mercury recedes as the temperature falls. The minimum thermometer contains alcohol, and an index is placed in the liquid. The tension of the surface of the alcohol causes sufficient force to be exerted on t[illegible] to draw it back as the temperature falls; as [illegible] temperature rises, the alcohol flows past the [illegible] i[illegible] long subject [illegible] pressure [illegible]ce. Thus [illegible] index [illegible]ins in the [illegible] occupied at the low[illegible] temperature registered [illegible] the thermometer was last set. The indexes may be brought into contact with the surface of the liquid by tilting the tube, or may be moved by a magnet. Other forms of apparatus are also used: in SIX'S THERMOMETER both indexes rest on the upper surface of a thread of mercury in a vertical U-tube, one end of which terminates in a bulb containing alcohol, which acts as the thermometer substance. In NEGRETTI & ZAMBRA'S THERMOMETER, which is a maximum thermometer only, there is a constriction in the bore through which the thread of mercury readily passes as the temperature rises; as the temperature falls again, the thread is interrupted at the constriction; the part below recedes into the bulb, but the part above remains in the position it occupied at the highest temperature, which is therefore easily read. This form of thermometer can be used in any position, and is therefore very suitable for use as a CLINICAL THERMOMETER for medical use.

Maximum Density of Water (*Phys.*) Water attains its maximum density at 4° C. *See* WATER and HOPE'S EXPERIMENT.

M.D. (*Music*). The right hand: the letters standing for the Italian *Man Diritta* and the French *Main Droite*. The equivalent in English is R.H.

Me (*Music*). The third note of the scale in the Movable Doh or Tonic Sol Fah System.

Mean. (1) Any quantity whose value is intermediate between two others. (2) An AVERAGE (*q.v.*)

Mean Free Path (*Phys.*) The mean or average distance which the molecules of a gas travel without coming into collision with other molecules.

Mean Noon (*Astron.*) The time at which the Astronomical Mean Sun (*q.v.*) crosses the meridian.

Mean Pressure (*Eng.*) The average pressure in a cylinder during the stroke. *See* INDICATOR DIAGRAMS, *etc.*

Mean Solar Day (*Astron.*) The interval between two successive mean noons (*q.v.*) This is the legal day observed in civil life, and its divisions give us the ordinary time of day. The latter differs from the Apparent Solar Time, which is shown on a sundial, by a small amount, termed the Equation of Time. The amount of this correction varies at different times of the year. In March, June, September, and December its value is zero; in February and August it has its maximum value, and ten minutes must be added to the Apparent Solar Time, or time by the sundial, to get the mean or legal time; in May and November the sundial time is in advance of the clock, and ten minutes must be subtracted from the former to obtain the Mean Solar Time.

Mean Sun, Astronomical. An imaginary point moving with uniform velocity round the Equator, and coinciding with the Dynamical Mean Sun (*q.v.*) at the points of intersection of the ecliptic and equator.

——, Dynamical (*Astron.*) An imaginary point moving with uniform velocity round the ecliptic, and always coinciding with the sun at perigee.

Measure (*Music*). A bar; that which is contained between two bar lines. Measure is the grouping of accent and non-accent, the bar line always preceding the strongest accent. *See* TIME.

Measurement. Measurement in general consists of the comparison of one magnitude with another, the latter constituting a standard of measurement. There are three fundamental standards, on which practically all measurements, however complex, ultimately depend—namely, the standards of Mass, Space, and Time. *See* STANDARDS OF MASS, SPACE, AND TIME, *and* WEIGHTS AND MEASURES. Measurements of mass are made by means of a BALANCE, SCALES, STEELYARD, SPRING BALANCE, etc. (*q.v.*) Measurements of length are commonly made by means of a graduated ROD, STAFF, RULE, SCALE, CHAIN, etc. (*q.v.*); more accurate measurements by means of CALIPERS, SCREW GAUGE, MEASURING MACHINE, READING MICROSCOPE, etc. (*q.v.*) Measurements of area are usually made by taking linear measurements and calculating the area by mensuration; measurements of volume may be made in the same way, or, in the case of fluids, by filling a vessel of known volume. Measurements of time may be made by comparison with the time of the swing of a PENDULUM (*q.v.*), the period of vibration of which is known from some previous observation. In ordinary measurements of time, in which a clock or watch is used, the pendulum (or its equivalent, the balance wheel) still furnishes the real unit of time, the mechanism serving for the purpose of recording the number of vibrations and also supplying the motive power by which the vibrations are maintained. The ultimate measurement of time depends entirely upon astronomical observations of the motion of celestial bodies; *e.g.* the transit (*q.v.*) of stars, the determination of noon, etc. Apart from the natural standards thus furnished, there is no definite unit of time whatever.

Measurement, Electrical. *See* AMMETER (*Appendix*), TANGENT GALVANOMETER, DYNAMOMETER, VOLTMETERS, RESISTANCE, WHEATSTONE BRIDGE, OHM'S LAW, *etc.*

Measurements of Temperature. Measurements of temperature are made in practice by the observation of certain physical changes produced in a suitable substance (termed the THERMOMETRIC SUBSTANCE) by changes of temperature. The chief physical properties utilised for thermometric purposes are as follows:

1. Volume of a liquid . (Common thermometers).
2. Pressure of a gas . } (Gas thermometer).
3. Volume of a gas . }
4. Length of a bar . . (Certain pyrometers).
5. Resistance of a conductor . . } (Platinum thermometer).
6. Electromotive force . (Thermo-electric couple).
7. Specific heat of a substance . . } (Indirect method).

(1) The common THERMOMETER consists of a capillary tube terminating in a bulb. A quantity of liquid (*e.g.* mercury or alcohol) is placed in the tube, sufficient to fill it when heated to a temperature slightly above the highest temperature to be observed by means of the instrument; the tube is sealed at the top while at this temperature. The FIXED POINTS are then found and marked on the tube. These are the levels at which the liquid stands in the capillary tube at certain standard temperatures; in ordinary cases the freezing point and the boiling point of pure water. The scale may now be constructed by dividing the distance between the marks on the tube into a convenient number of parts or DEGREES. *See* CENTIGRADE, FAHRENHEIT, *and* REAUMUR SCALES. The WEIGHT THERMOMETER also depends upon the variation in the volume of a liquid. If a bulb be completely filled by a weight w_0 of some suitable liquid at 0° C., and w_t the weight which fills it at a temperature $t°$, then the value of t is given by the equation

$$t = \frac{w_0 - w_t}{w_t}$$

(2 and 3) The GAS THERMOMETER depends upon the changes in pressure of a gas at constant volume, due to changes of temperature, or (less frequently) upon its changes of volume at constant pressure. Thus let P_0 and V_0 be the pressure and volume at 0° C., P_t and V_t the values at t°, and a the coefficient of increase of pressure at constant volume (or increase of volume at constant pressure); then

$$P_t = P_0 (1 + at)$$
$$V_t = V_0 (1 + at)$$

Thus if a be known and P (or V) be observed at 0° and at t°, the value of t may be readily found. The gas thermometer has a very wide range of temperatures, over which its readings are reliable. (4) A PYROMETER is a form of thermometer especially adapted to the measurement of very high temperatures. The early forms depended upon the measurement of the expansion of a bar of metal, porcelain, fireclay, etc. The indications of these instruments were very uncertain, and they are now replaced by the ELECTRICAL RESISTANCE THERMOMETER or PLATINUM THERMOMETER. (5) This depends upon the increase in the resistance of a platinum wire as the temperature rises. The rate of increase of resistance is very nearly a constant, and may be expressed to a first approximation by the equation

$$R_t = R_0 (1 + at),$$

where R_t equals the resistance at t°, R_0 the resistance at 0°, and a is the coefficient of increase of resistance with temperature. The coefficient may be found by observing the resistance of the instrument at 0° and 100° C. To obtain greater accuracy, a further correction (termed the "delta correction") must be introduced; this requires the use of a second constant, whose value may be found by measuring the resistance of the wire at a third known temperature. For this purpose the boiling point of sulphur (444·53° C. at the normal atmospheric pressure of 760 millimetres) is used as a standard. The platinum thermometer affords the best scientific method of measuring temperature; not only has it a very extensive range, but it is capable of detecting very minute changes; *e.g.* $\frac{1}{10000}$ of a degree Centigrade—a sensitiveness far beyond any liquid or gaseous thermometer. (6) A thermo-electric junction affords a very convenient, though less accurate, method of measuring temperatures. A "couple" consisting of two pieces of dissimilar metals in the form of wire twisted together is connected in series with a suitable galvanometer. The deflection of the galvanometer will depend upon the E.M.F. at the junction, and the scale may be graduated to read directly in degrees within a wide range. The thermo-electric couple has been much used in experimental work in metallurgy, and is now being applied to many practical purposes in the same science. (7) The remaining method only gives an approximate measurement. A solid of known specific heat (*q.v.*) is heated up to the temperature which it is desired to measure (*e.g.* by placing it in a furnace), and, when hot, is dropped into a vessel of water or other liquid of known specific heat. From the rise in temperature of this liquid the heat given out by the solid can be found, and hence its temperature at the instant when it was introduced into the liquid. A correction must be made for the amount of liquid which was turned into vapour by the hot solid at the time of first entering the liquid.

Measures. *See* WEIGHTS AND MEASURES.

Measuring Machine (*Eng.*) An appliance resembling in principle a large SCREW GAUGE (*q.v.*), introduced by Whitworth for the accurate comparison of small standards of length by means of end measurement.

Meat (*Foods*). As an article of diet meat furnishes proteid, fat, and salts. As a rule "white meat," such as fowl and rabbit, contains less nitrogen, and is more tender and digestible than "red meat," such as beef, mutton, and game. The muscles of this latter class of meat should be firm and elastic to the touch; moist, but not wet; of a deep red colour except in the case of veal and pork; and marbled with fat. The fat should be firm and whitish yellow in colour, and free from bloodstains. The marrow of the bones should be light red. If putrefaction has begun the meat is pale and soft; a knife or skewer thrust in and rapidly withdrawn will smell offensively. *See* FOODS.

Mechanical Air Pumps. *See* AIR PUMPS.

Mechanical Characteristic (*Elect. Eng.*) A curve showing the ratio of TORQUE and SPEED (*q.v.*) in an electric motor.

Mechanical Cut Out (*Elect. Eng.*) Any arrangement for breaking a circuit which is not worked electrically.

Mechanical Deposits (*Geol.*) This term includes various forms of sedimentary rocks, such as sandstones, breccias, conglomerates, boulder clays, etc., in

contradistinction to limestones, coal seams, oil shales, etc., and rocks of eruptive origin.

Mechanical Engineering. A comprehensive term for the science and art of designing, casting, forging, machining, fitting and erecting machines, metal structures, etc.

Mechanical Equivalent of Heat. *See* JOULE'S EQUIVALENT.

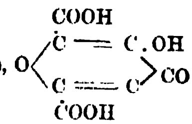
Mechanical Operations. Operations carried out by a machine, either entirely automatic or partly worked or controlled by hand.

Mechanical Wood (*Paper Manufac.*) A term applied to wood pulp prepared by the mechanical process. *See* WOOD PULP.

Mechanics. The science dealing with forces and their effects upon matter.

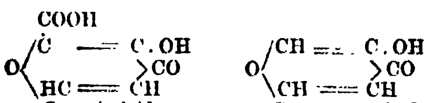
Mechanism. A term often used synonymously with MACHINE (*q.v.*): the arrangement and relation of the parts of a machine. Scientifically it is applied to an ideal or theoretical combination of moving parts having the kinematical properties of a machine or of some portion or "element" thereof.

Meconic Acid (*Chem.*),



(2:6-dicarboxy-3-hydroxy-γ-pyrone).

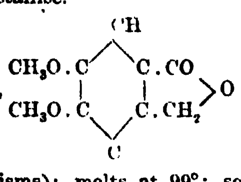
A white crystalline solid (scales or prisms) which contains 3 molecules water of crystallisation; soluble in water, more so in alcohol; gives a red colour with ferric chloride; boiled with water it gives comenic acid; heated alone, it yields first comenic acid, then pyromeconic acid—



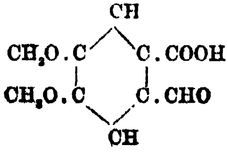
Comenic Acid. Pyromeconic Acid.

It occurs united with the alkaloids in opium, and is extracted from the latter by treatment with warm water, neutralisation with chalk, concentration of the solution, and addition of calcium chloride, when calcium meconate crystallises out; from the salt the acid is obtained by boiling with hydrochloric acid and allowing to crystallise.

Meconin (*Chem.*),



White crystals (prisms); melts at 99°; soluble in alcohol; occurs in opium; it is obtained when narcotine is reduced by zinc and sulphuric acid; also when opianic acid is reduced by sodium amalgam. Opianic acid has the formula



Mediæval. In regard to art this generally applies to the period between the twelfth and sixteenth centuries. Historically speaking, it covers a period of about a thousand years, *viz.* from the middle of the fifth century to the capture of Constantinople by the Turks in 1453.

Mediant (*Music*). The technical name for the third degree of the scale, lying midway between tonic and dominant.

Medicinal Soaps. That class of toilet soaps which are specially made for benefiting the skin, or to assist in curing certain diseases, such as tar soap, turpentine soap, and other special mixtures used for eczema, cases of rough skins, etc.

Medium (*Paint.*) The liquid vehicle with which pigments are mixed for painting, *e.g.* linseed oil, magilp.

—— (*Paper Manufac.*) Printing paper measuring 24 by 19 in. Writing paper measuring 22 by 17½ in.

Medlar (*Botany*). The medlar is the fruit of *Mespilus germanica* (order, *Rosaceæ*). The five large sepals surmounting the fruit are distinctive of the genus.

Medulla (*Biol.*) (1) A term often applied to a substance forming the internal portion of an organic structure, *e.g.* the PITH of a plant stem, the pithlike substance in the axis of a feather. (2) The MEDULLA OBLONGATA is the hinder portion of the brain.

Meerschaum (*Min.*) A hydrous silicate of magnesium, $2MgO.3SiO_2.2H_2O$. Silica = 60·8, magnesia = 27·1, water = 12·1 per cent. Amorphous; white or greyish; can be scratched by the finger nail. It is used principally for the making of pipes; in Algiers as a substitute for soap; and as a building stone in Spain. The best samples are from the Levant and Asia Minor.

Meeting Rails (*Joinery*). Rails that meet together, *e.g.* the rails of double hung sashes.

Meg- *or* **Mega.** A prefix indicating that the unit, etc., is multiplied one million times, *e.g.* MEGOHM, one million ohms.

Megalithic (*Architect.*) Composed of large stones. *See* PREHISTORIC ARCHITECTURE.

Megohm (*Elect.*) One million OHMS (*q.v.*)

Megohm Standard (*Elect.*) A standard coil of one megohm resistance. Used in measuring high resistances, such as those of insulating materials.

Meissen. *See under* DRESDEN CHINA.

Meizoseismic. A term applied to the line or curve of maximum disturbance effected by an earthquake.

Melanite (*Min.*) A black variety of Garnet (*q.v.*)

Melanterite (*Min.*) Hydrous sulphate of iron, $FeSO_4.7H_2O$. Sulphuric acid = 28·5, water = 45, ferrous oxide = 26·5 per cent. Monosymmetric; green to white when fresh; often yellow or brown after exposure. Often occurs as a pulverulent incrustation. A frequent product of the decomposition of Pyrites. In quantity at Goslar in the Harz, and in Ohio. *See also* COPPERAS.

Melaphyre (*Geol.*) A term which was formerly used to denote a basalt that has undergone changes in composition through the prolonged action of percolating waters.

Melde's Experiment (*Sound*). An experiment for showing the laws of vibration of strings. One end of a string passes over a pulley, and is attached to a

weight; the other end is attached to the prong of a large tuning fork, by means of which the string is set in vibration.

Mellow (*Carp.*) A term applied to timber which is thoroughly dry and in good condition for working.

Mellowing (*Leather Manufac.*) Applied to tan liquors means ageing and souring of the liquor with diminution of astringency. Applied to leather, means the softening of hard, harsh leather. This is generally attained by allowing the leather to lie in pile to absorb moisture, the process being assisted by damping and stretching or staking.

Melody (*Music*). An orderly succession of different single sounds.

Melting. The fusion of a substance. Distinguished from SMELTING (*q.v.*), which is fusion, accompanied by chemical or other changes in the substance which is being treated.

Melting Point (*Phys., etc.*) The temperature at which a substance fuses under ordinary conditions of pressure.

——, **Effect of Pressure on** (*Phys.*) Substances which expand on melting have their melting point raised by increase of pressure; those which contract on melting (*e.g.* ice) have their melting point lowered by pressure.

Melting Pot (*Glass Manufac.*) A crucible used in GLASS MANUFACTURE (*q.v.*)

—— (*Plumb.*) An iron pot for melting lead and solder.

Member (*Architect.*) A moulding; *e.g* (1) An architrave may consist of two or more members. (2) The crowning moulding of a cornice is its upper member.

—— (*Eng., etc.*) A single portion of a structure or machine.

Membered (*Her.*) Said of the beak and legs of a bird when they differ in tincture from the body.

Membrane (*Biol.*) Tissue in the form of a thin sheet.

Menaccanite (*Min.*) A variety of ILMENITE (*q.v.*)

Mending (*Cloth Manufac.*) The operation of repairing broken threads and picks and defective places in the piece after weaving. It may involve the insertion of lengths of thread, the mender having carefully to follow the order of interlacing in weaving.

Mending Up (*Foundry*). *See* MAKING UP.

Mending Up Piece (*Foundry*). A strip of wood (or metal) which is bent to the shape of the edge of a mould, and held in place while sand is rammed against it to repair a broken edge, in MENDING UP (*q.v.*)

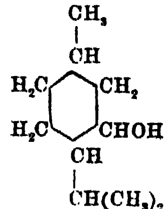
Menhirs (*Architect.*) *See* PREHISTORIC ARCHITECTURE.

Menilite (*Min.*) A variety of OPAL from near Paris; it occurs in rounded concretionary masses of a liver colour.

Meno (*Music*). Less; *meno mosso*, less movement: somewhat slower.

Mensuration. The calculation of the areas and volumes of figures and solid objects.

Menthol (*Chem.*),



(Methyl-1-isopropyl-4-cyclohexanol-3).

A white crystalline solid smelling of peppermint; melts at 42°; lævorotatory; very soluble in alcohol and in chloroform. On reduction it yields hexahydrocymene; on oxidation it yields menthone (*q.v.*); dehydrating agents convert it into menthene

$$CH_3.CH\left\langle\begin{smallmatrix}CH_2 - CH \\ CH_2 - CH_2\end{smallmatrix}\right\rangle C.CH(CH_3)_2.$$

Menthol occurs in oil of peppermint (50 to 65 per cent.), from which it is prepared by freezing. Used in medicine because it produces local anæsthesia.

Menthone (*Chem.*) The ketone corresponding to menthol (*q.v.*); it is a liquid smelling of peppermint and having a bitter taste; boils at 206°. It occurs along with menthol in oil of peppermint, and can be separated from this by conversion into menthone oxime. It is prepared from menthol by oxidation with potassium dichromate and sulphuric acid.

Mentonière (*Arm.*) A piece of defensive armour which was generally attached to the breastplate, and formed a protection for the neck, chin, and the lower half of the face. Literally a chin piece.

Mercaptans (*Chem.*) Alcohols in which the oxygen is replaced by sulphur. They are also called thioalcohols or hydrosulphides, *e.g.*

CH_3OH	CH_3SH
Methyl Alcohol.	Methyl Mercaptan.

Ethyl mercaptan, commonly called mercaptan, is the most important member of the series, and it is described as typical of all other mercaptans. It is a colourless liquid with peculiar garlic smell, which is very persistent; boils at 36·2°; soluble in water; the solution deposits crystals, $C_2H_5SH18H_2O$, on cooling. On oxidation with nitric acid it yields ethyl sulphonic acid. The hydrogen of the hydrosulphide group is easily replaceable by metals when mercaptides are formed; it was on account of the ease with which ethyl mercaptan unites with mercuric oxide to form mercury mercaptide, $(C_2H_5S)_2Hg$, that it received the name mercaptan. Mercaptan condenses with aldehyde in presence of hydrochloric acid to form a mercaptal ethidene mercaptal—

$$CH_3.CH\left\langle\begin{smallmatrix}SC_2H_5 \\ SC_2H_5\end{smallmatrix}\right.$$

Mercaptan is used in the manufacture of sulphonal (*q.v.*) Methyl and ethyl mercaptans are decomposition products of albumins. Mercaptan is prepared by distilling solutions of potassium hydrosulphide and calcium ethyl sulphate; it can also be prepared by distilling alcohol with phosphorus pentasulphide. Aromatic mercaptans can be prepared by reduction of the sulphonic acid chlorides, *e.g.*

$$C_6H_5SO_2Cl \xrightarrow[H]{} C_6H_5SH.$$

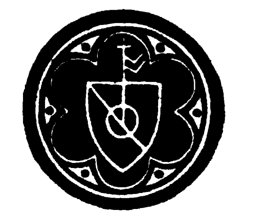
Mercerisation. In the year 1844, John Mercer, a Lancashire calico printer, made the discovery that when a cotton fabric is immersed in a cold solution of caustic soda or potash, within certain limits of

concentration, the strength of the fibre and its power of attracting colouring matters are considerably increased. This alteration in properties is accompanied by a contraction of the material which may even amount to 25 per cent. of its area. Although Mercer patented his discovery in 1850, and was offered £40,000 by a French firm for the patent rights (an offer which he refused), the process was not worked successfully in his day on a commercial scale, owing to the contraction of the fabric and the cost of working. This treatment with caustic soda became known as MERCERISING; but the process remained almost purely theoretical in its interest until it was revived nearly fifty years later for the production of crimped or *crêpon* effects. When certain portions of a cotton fabric are printed with, or otherwise subjected to, the action of caustic soda solutions of a certain strength, whilst other parts are protected from this action, the treated portions become mercerised and contract, which brings about a crinkling or puckering of the untreated areas. The operation to which the name "mercerising" is chiefly applied at the present time dates from 1895. In that year the patents of THOMAS & PREVOST set forth that if the contraction of cotton fabrics or yarns, due to mercerisation, be prevented by subjecting the material to a sufficient tension during the operation, the cotton is not only made stronger and capable of being dyed more deeply with the same quantity of colouring matter, but it also acquires an enhanced lustre, resembling, though not equal to, that of silk. The validity of Thomas & Prevost's patents was successfully contested on the ground that the invention had been anticipated in the English patent granted in 1890 to LOWE, who appears, however, not to have appreciated the full import and commercial value of the discovery. This mercerising or "lustreing" process is now carried out on a very large scale on cotton yarn and cloth, and mercerised cotton has replaced silk in certain of its industrial applications. Various types of machine exist for performing the necessary operations, but whatever the particular method of working, the material is treated with caustic soda by immersion or by sprinkling while in a stretched condition, well washed with water without relaxing the tension, and passed through an acid bath to complete the removal of alkali. If desired, a silk-like "scroop" is imparted by passages through successive baths containing soap solution and dilute acid. Only certain varieties of cotton yield a high degree of lustre by this treatment, *viz.* the long-stapled Egyptian and Sea Island cottons. Caustic soda below 15° Tw. has no mercerising action; the best results are obtained with a lye of 45° to 55° Tw. (S.G. 1·22 to 1·27) at a temperature not exceeding 70° F. The duration of the treatment has little influence. The CHEMICAL CHANGE involved in mercerisation is the formation of a stable cellulose hydrate, $(C_6H_{10}O_5 \cdot H_2O)_n$. The appearance of the fibre undergoes alteration, the cell walls thicken, the central cavity almost disappears, and the fibres become much rounder. In DYEING mercerised cotton the direct dyestuffs are chiefly employed, since mordanting operations usually bring about a diminution of the lustre; for very bright shades the direct dyes are "topped" with basic colours. The lustre of mercerised fabrics is frequently increased by means of mechanical finishing operations—*e.g.* the SCHREINER FINISH, which consists of passing the material under a heated roller engraved with a large number of very fine lines; this breaks up the surface of the material into innumerable minute reflecting surfaces. Other mercerising agents besides caustic soda have been suggested; Mercer himself mentioned sulphuric acid and zinc chloride. Analagous processes applicable to wool and silk have also been described as "mercerisation," *e.g.* a treatment with caustic alkali at 32° F., but these have not found any extended application.—R. B.

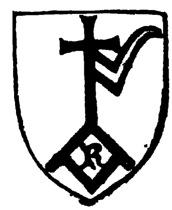
Mercerised Cotton. *See* CELLULOSE *and* MERCERISATION.

Merchant Iron. Wrought iron bar, ready for putting on the market.

Merchant Marks (*Archæol.*) From earliest times it has been found necessary to have some distinguishing personal mark by which to identify an owner. With regard to those who had the right to wear coat armour, there was no difficulty; the heralds took care that only those entitled to have armorial bearings used them. With respect to citizens and merchants, there arose the custom of identifying their goods by what are now termed "merchant marks." Hence we find the following in the Harleian MSS.: "Theys be none Armys, but a marke as merchaunts use, for euery man may take hym a marke; but not armys without a herawde or purcyuante." Though alluded to in a slighting manner in the foregoing extract, yet these marks were protected by the laws of the realm equally as jealously as the coats of arms. They occasionally appear on monuments, etc., in conjunction with coats of arms. The marks originally showed the deep

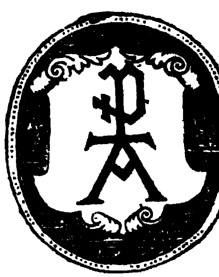


GREVEL, CHIPPING CAMPDEN, 1401.



PAGGE, CIRENCESTER, 1440.

religious feeling which underlay all the transactions of everyday life, and generally consisted of a cross or a variant of the same. Another frequent form was shaped like the Arabic numeral 4, in which the cross may be again noted. The woolstaplers looked to St. John Baptist as their patron; consequently they utilised his emblems, the lamb and cross with streamers. The initials of the owner were often added, and in later times, when the cross disappeared, monograms and conventional forms were used, which survive at the present time under the designation of Trademarks.



PARKER, IPSWICH, 1590.

Mercury (*Astron.*) The planet nearest the sun. Distance from sun, 35,750,000 miles; diameter, about 3,000 miles; periodic time, 88 days.

—— (*Chem.*) Hg. Atomic weight, 200·3. A silvery white liquid; melts at −39°; boils at 358°. It has a vapour density equal to half its atomic weight, from which it is concluded that mercury has a monatomic molecule. It slowly combines

with oxygen at a temperature near its boiling point, forming the red oxide in crystalline form; with many other elements, it unites even at the ordinary temperature—for example, with the halogens and sulphur and many metals. Combinations of mercury and other metals are called amalgams; some of them appear to be definite compounds. The action of acids is as follows:—Hydrochloric acid—no action; hydriodic acid forms the iodide which dissolves in the acid; nitric acid—cold and dilute, forms with excess of mercury mercurous nitrate, the hot acid in excess forms mercuric nitrate; sulphuric acid—hot and concentrated, forms mercurous sulphate if the metal is in excess, mercuric sulphate if the acid is in excess. Mercury occurs naturally chiefly as sulphide, which is called cinnabar; to a much smaller extent it occurs free. It is obtained from the ore by a simple roasting process, $HgS + O_2 = Hg + SO_2$: but elaborate condensing arrangements are required to recover all the vapour. Commercial mercury or mercury which has been much used in the laboratory is impure; such mercury is purified by distilling under greatly reduced pressure or by allowing it to stand under dilute nitric acid, when less easily oxidised metals than mercury go into solution, because such metals throw out mercury from solutions of its salts. Mercury is largely used in the construction of scientific apparatus, such as thermometers, barometers, air pumps, standard cells, etc.; it is also used in medicine in various forms, *e.g.* grey powder is mercury and chalk; blue pill is mercury, lard, and suet.

—— (*Min.*) This element is found native in a disseminated state in some shale and in disintegrated granite. The chief localities are Almaden in Spain, and Idria in Austria. When artificially frozen it crystallises in the cubic system. The chief ores of mercury are Amalgam, Cinnabar, and Calomel. Cinnabar alone is commercially important as an ore.

Mercury Air Pump. *See* AIR PUMPS.

Mercury Break (*Elect.*) A device for making and breaking a current by means of a vibrating conductor, which is caused to dip into a vessel of mercury.

Mercury Compounds (*Chem.*) Mercury forms three classes of compounds, namely the mercurous compounds, the mercuric compounds, the mercury ammonium compounds. *Mercurous Compounds*:—MERCUROUS OXIDE, Hg_2O, is a black powder, easily decomposed by light or on heating to mercury and mercuric oxide. It is obtained by the action of caustic soda or potash in slight excess on a mercurous salt. MERCUROUS CHLORIDE, Hg_2Cl_2, commonly called CALOMEL, is a yellowish white powder which sublimes without melting or heating. The vapour density of ordinary calomel is 118, or half that required by the formula Hg_2Cl_2: this is due to dissociation into mercuric chloride and mercury. When calomel is dried by allowing it to remain in a vapour density apparatus containing phosphorus pentoxide for several days, its vapour density is nearly normal. Calomel is practically insoluble in water (3 parts in 1,000,000); it is soluble in boiling hydrochloric acid, but this is due to conversion to mercuric chloride. For action of caustic soda or potash see the OXIDE. Ammonia turns it black, owing to formation of a mixture of dimercurammonium chloride and mercury. It is obtained (1) by precipitating a solution of mercurous nitrate with hydrochloric acid in slight excess, filtering and well washing the precipitate; (2) by subliming an intimate mixture of mercuric chloride and mercury and thoroughly washing the sublimate. Calomel is used in medicine. MERCUROUS NITRATE, $Hg_2(NO_3)_2$: A white crystalline solid; the crystals contain $2H_2O$; soluble in a small quantity of water; hydrolysed by much water, forming a basic nitrate. The ordinary solution is made by adding a little nitric acid to the water in which it is to be dissolved. It is the only common soluble mercurous salt. MERCUROUS IODIDE, Hg_2I_2: Yellow tetragonal tablets; sublimes on heating gently; rapidly heated it decomposes, with liberation of mercury. Prepared by boiling a solution of mercurous nitrate containing a little nitric acid with excess of iodine, and allowing the clear liquid to crystallise. The green compound obtained by precipitating mercurous nitrate with potassium iodide is probably not pure, as mercurous iodide is decomposed by potassium iodide, $Hg_2I_2 + 2KI = K_2HgI_4 + Hg$. *Mercuric Compounds*:—MERCURIC OXIDE, HgO, also called RED PRECIPITATE, exists in two forms, yellow and red. According to Ostwald the difference is due to the yellow form being more finely divided than the red. According to Schoch the two forms are really distinct, the yellow form crystallising in square tablets and the red in prisms; also the yellow form has a higher dissociation pressure than the red. It is slightly soluble in water; decomposed on heating. The yellow variety is more active chemically than the red; for example, it gives chlorine monoxide with chlorine, while the red does not. Acids yield corresponding mercuric salts. The yellow oxide is obtained by adding a solution of caustic soda or potash to a solution of mercuric chloride. The red oxide is obtained by heating mercuric nitrate alone, or, more economically, by heating an intimate mixture of the nitrate and mercury. Both oxides are used in medicine. MERCURIC CHLORIDE, $HgCl_2$, also called CORROSIVE SUBLIMATE: A white crystalline solid (needles). Melts at 288°; boils at 303°. Moderately soluble in water, much more soluble in ether and alcohol. Its aqueous solution has about the same electrical conductivity as water, so that it is only feebly ionised. This accounts for several peculiarities in its chemical behaviour; for example, it is not decomposed by concentrated sulphuric or nitric acids. It is very poisonous. Its solution coagulates albumen; hence the use of white of egg as an antidote in corrosive sublimate poisoning, the latter forming an insoluble compound with the former. With solution of caustic soda or potash it gives the yellow oxide; with ammonia it gives a white precipitate, $NHg_2Cl.NH_4Cl$. *See below*. Its solution dissolves mercuric oxide, forming various oxychlorides. Hydrochloric acid readily dissolves mercuric chloride, forming the compound $HHgCl_3$. Mercuric chloride forms many double salts with the alkaline chlorides, *e.g.* $KHgCl_3$ and K_2HgCl_4, and similar salts with NaCl and NH_4Cl, which are more soluble than mercuric chloride in water. $(NH_4)_2HgCl_4 . H_2O$ is SAL ALEMBROTH. Mercuric chloride is prepared by subliming a mixture of common salt and mercuric sulphate, to which a little manganese dioxide has been added, to prevent the formation of calomel from any mercurous sulphate which may be present in the mercuric sulphate. It can be obtained by the action of chlorine on mercury, and therefore of *aqua regia* on mercury. *Also see above*. It is very largely used as an antiseptic and bactericide. MERCURIC IODIDE, HgI_2: Exists in two forms—yellow rhombic prisms and red quadratic prisms, the latter being the stable form at

ordinary temperatures. The transition temperature is 126°; that is, above this temperature the yellow is the more stable form, and below it the red. When the vapour of mercuric iodide is condensed, or when the iodide is formed by precipitation, the yellow form is produced first, and the change from yellow to red is accelerated by light; when the vapour is condensed in the presence of crystals of each form, then both forms are produced. At the boiling point of liquid air the red form becomes orange, and the yellow form white. Melts at 253°. Solubility in water, 0·5 parts in 1,000,000 at 18°; much more soluble in hot solution of potassium iodide or hot concentrated hydrochloric acid, from which it can be crystallised; soluble in alcohol. It forms many double salts; for example, K_2HgI_4. It is prepared by grinding mercury and iodine together in a mortar in presence of a little alcohol, also by precipitating a solution of mercuric chloride with potassium iodide. It is used in medicine. MERCURIC NITRATE, $Hg(NO_3)_2$: A white crystalline solid, soluble in water, containing a little nitric acid. Forms basic salts with water, *e.g.* $Hg(NO_3)_2 2Hg(OH)_2$. On heating it gives the red oxide. It is formed by dissolving mercury in hot nitric acid, using small excess of the latter, and crystallising by allowing to stand over sulphuric acid. Used in medicine. MERCURIC SULPHATE, $HgSO_4$: A white crystalline solid, soluble in water, containing sulphuric acid. Decomposed by water, forming basic salts, *e.g.* $HgSO_4 2Hg(OH)_2$. Obtained by boiling mercury with excess of sulphuric acid. Used in preparation of artificial indigo. *See* INDIGO. MERCURIC SULPHIDE, HgS: The natural sulphide is called "cinnabar," and the artificial variety, prepared for use as a pigment, is called "vermilion." Mercuric sulphide exists in two forms: a black amorphous form and a red crystalline form which is more stable than the black form. When the black form is sublimed out of air it passes into the red form; the same change occurs when the black form is allowed to stand in a solution of an alkaline sulphide, the reason being that the black variety is more soluble in such a solution than the red variety, so that the solution is always saturated with respect to the black and supersaturated with respect to the red form. On heating out of air, mercuric sulphide sublimes without melting; its vapour density is below the normal, so that dissociation occurs. Heated in air it gives mercury and sulphur dioxide. Heated with diluted nitric acid it forms a white compound, $Hg(NO_3)_2 2HgS$. This compound and a similar white compound, $HgCl_2 2HgS$, are formed when sulphuretted hydrogen is passed into a solution of the nitrate and chloride respectively, in amount insufficient for complete precipitation: both are decomposed by excess of the gas. *Aqua regia* converts the sulphide into chloride with separation of sulphur. The black form is obtained by grinding mercury and sulphur together, or by precipitating a solution of the chloride with excess of sulphuretted hydrogen. The red form is obtained from the black, as mentioned above. It is used as a paint. *See* VERMILION. MERCURIC CYANIDE, $Hg(CN)_2$: A white crystalline solid (prisms), easily soluble in water. The aqueous solution is a non-conductor of electricity, and it shows the normal lowering of the freezing point; so the salt is not ionised, and therefore does not give the ordinary tests for mercury or for a cyanide. It is decomposed by sulphuretted hydrogen, also by hydrochloric acid. On heating, it decomposes into mercury and cyanogen, a part of the latter polymerising. It combines with mercuric oxide to form a basic cyanide, $HgO . Hg(CN)_2$, and forms many double salts, *e.g.* $K_2Hg(CN)_4$. It is obtained by boiling Prussian blue with mercuric oxide and water,

$$2Fe'''_4\{Fe''(CN)_6\}_3 + 21HgO + 21H_2O = 18Hg(CN)_2 + 14Fe(OH)_3 + 3Hg,$$

also by boiling potassium ferrocyanide with mercuric sulphate and water,

$$2K_4Fe(CN)_6 + 7HgSO_4 = 6Hg(CN)_2 + 4K_2SO_4 + Fe_2(SO_4)_3 + Hg,$$

and very conveniently by dissolving yellow mercuric oxide in a slight excess of hydrocyanic acid (dilute). Mercury combines with many alcohol radicals. MERCURY METHYL, $Hg(CH_3)_2$, may be taken as an example of these compounds. It is a colourless liquid; boils at 95°. Its vapour is very poisonous. Insoluble in water, readily soluble in alcohol and ether; takes fire on gentle heating in air. With iodine it yields mercury methyl iodide, $HgCH_3I$, and the same compound is obtained when methyl iodide and mercury are exposed to sunlight. Mercury methyl is obtained by the action of sodium amalgam on methyl iodide in presence of ethyl acetate, or when mercury methyl iodide is distilled with caustic potash. "Sublamin" is a compound of ethylene diamine with mercuric sulphate,

$$\{C_2H_4(NH_2)_2\}_3\{HgSO_4\}_2,$$

which is used like corrosive sublimate as an antiseptic. *Mercury Ammonium Compounds:*—Compounds in which divalent mercury replaces the hydrogen of the ammonium group, $(NH_4)'$. DIMERCURAMMONIUM OXIDE, $(NHg_2)_2O$, is a dark brown explosive powder, obtained by the action of liquid ammonia on mercuric oxide. The hydroxide corresponding to this oxide, NHg_2OH, is a pale brown powder obtained by heating its hydrate, $NHg_2OH . 2H_2O$, at 80° to 85°; the hydrate is formed as a pale yellow powder when mercuric oxide is warmed with dilute ammonia. The salts of this oxide are formed from it by the action of acids. Of these salts the following are important: The HYDRATE OF DIMERCURAMMONIUM IODIDE, $NHg_2I . H_2O$. This is the substance formed when Nessler's reagent is used to test for ammonia, $2HgI_2 + 3KOH + NH_3 = NHg_2I . H_2O + 3KI + 2H_2O$. WHITE PRECIPITATE (INFUSIBLE), $NH_4Cl . NHg_2Cl$: A double salt of ammonium chloride and dimercurammonium chloride, called infusible because it decomposes without melting, when heated, into calomel, ammonia, and nitrogen. It is formed by adding ammonia to a solution of corrosive sublimate. It is used in medicine. WHITE PRECIPITATE (FUSIBLE) is probably $NHg_2Cl . 3NH_4Cl$, and is formed by boiling the last compound with a solution of ammonium chloride.—W. H. H.

Mercury Gauge. An instrument for measuring the pressure of a liquid or gas by observation of the height of a column of mercury necessary to balance the pressure under consideration. This device is much used in physical measurements; it was at one time used in engineering to measure steam pressure; its chief use in engineering is now for testing the graduations of Bourdon and similar pressure gauges.

Mercury Vapour Lamp, Hewitt's (*Elect.*) A long vacuum tube containing a quantity of mercury at the lower end, at which is the negative pole. The lamp will work with the ordinary voltage of an electric supply, but requires a spark from an induction coil to start it. The light is very unpleasant in

colour, but extremely economical. It is said to require from one third to one half of a watt per spherical candle power (*q.v.*), whereas the ordinary incandescent electric lamp requires four watts. The lamp can be used with any voltage from 100 to 1000, and with a current up to 100 ampères, either direct or alternating. With the latter, however, the difficulties of starting are greater than in the case of a direct current; when started, the current flows in one direction only.

Mericarp (*Botany*). The term applied to the two parts (each containing one seed) of the fruit of the *Umbelliferæ*, *Labiatæ*, and other orders. The caraway "seed" is a mericarp.

Meridian. (1) Midday or noon; figuratively the culmination. (2) One of the innumerable imaginary lines or circles on the surface of the earth passing through the North and South Poles and through other given places, and employed for denoting the longitude of places. The FIRST MERIDIAN is that from which all others to the eastward or westward are counted, usually the meridian of Greenwich.

—— (*Astron.*) A great circle passing through the celestial poles, zenith, and nadir (*q.v.*) It is therefore at right angles to the horizon.

Meridian Circle (*Astron.*) A transit instrument fitted with circles by means of which the north polar distances or declinations of stars can be determined.

Meridian, Magnetic (*Phys.*) The vertical plane in which are situate the two points on the horizon towards which the magnetic needle points.

Meridian Mark (*Astron.*) If a transit instrument is used for making long series of observations, a permanent meridian mark is made to assist in determining the azimuth constant.

Meridian, Terrestrial. A great circle (*q.v.*) on the earth, passing through the terrestrial poles. It crosses the equator at right angles.

Merino (*Textile Manufac.*) Fine worsted dress fabric.

Merions (*Architect.*) *See* BATTLEMENT.

Mermaid (*Her.*) This mythical being is used as a charge or badge in heraldry; example, the Berkeley brass, 1392.

Merohedrism (*Min.*) A term including both the types of development of crystal faces known as HEMIHEDRISM and TETARTOHEDRISM (*q.v.*)

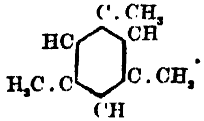
Meros (*Architect.*) The flat space between the channels or glyphs of a triglyph. It is also known as a FEMUR. *See* TRIGLYPH

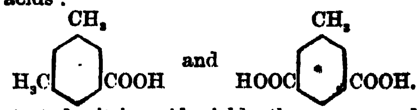
Mesentery (*Zool.*) The membrane which surrounds and supports the intestines of an animal.

Mesh. The openings in a net, sieve, or woven fabric; also a general term for similar openings in other objects.

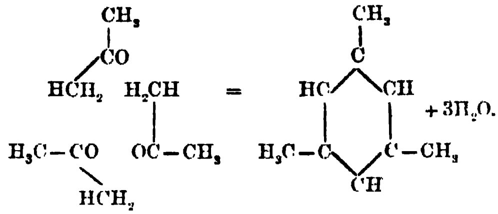
—— (*Lace Manufac.*) A mesh of net is one complete hole.

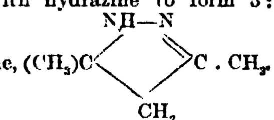
Mesh Connection *or* **Grouping** (*Elect. Eng.*) An arrangement of the coils of a three phase motor in the form of the Greek letter Δ.

Mesitylene (*Chem.*),  (*Symmetrical trimethylbenzene.*) A colourless liquid smelling like benzene; boils at 164°. Halogens in the dark replace the hydrogen of the nucleus; at the boiling point they enter the side chains. Boiled with dilute nitric acid, it is oxidised to mesitylenic and uvitic acids:



Concentrated nitric acid yields the mono- and di-nitro derivative; fuming nitric and sulphuric acids yield the tri-nitro derivative. Mesitylene occurs in coal tar; it can be prepared by allowing acetone to stand with excess of sulphuric acid and distilling the product. This method of formation is a proof of its constitution.



Mesityl Oxide (*Chem.*) $(CH_3)_2.C:CH.CO.CH_3$. A colourless liquid smelling like peppermint, boils at 132°; unites with bromine to form a dibromide; with ammonia to form diacetoxamine, $(CH_3)_2CNH_2.CH_2CO.CH_3$; with hydrazine to form 3:5:5-tri-methyl pyrazoline, 

Heated with dilute sulphuric acid it yields acetone. It is prepared by passing hydrochloric acid gas into cold acetone, allowing to stand, washing with caustic soda, distilling in steam, and fractionally distilling the product to separate phorone (*q.v.*)

Mesolite (*Min.*) A hydrous calcium aluminium sodium silicate of complex formula. Triclinic, occurring in delicate capillary crystals. It is one of the ZEOLITES (*q.v.*) From vapour cavities in volcanic rocks near Edinburgh, in Skye, Antrim, etc.

Mesotartaric Acid (*Chem.*) *See* TARTARIC ACID.

Mesozoic (*Geol.*) One of the larger subdivisions of the geological time scale. It embraces all the rocks below the base of the Eocene strata down to that of the Trias or Upper New Red. When the fossils of the Dyas or Lower New Red are better understood the base of the Mesozoic group of rocks will include also that subdivision of the New Red. The name refers to the fact that the forms of life represented in the Mesozoic rocks are intermediate in character between the Palæozoic times and those of the present day.

Mesto (*Music*). Sadly.

Metacentre (*Hydrostatics*). If a vertical line be drawn through the centre of gravity of a floating body when at rest, it will pass through the centre of gravity of the liquid which is displaced by the body. If now the latter be moved from its position of equilibrium, the centre of gravity of the displaced liquid will no longer be in this line, and a new vertical line drawn through it will intersect the former line in a point which is termed the META-

CENTRE. If the metacentre be above the centre of gravity of the body, the latter is in stable equilibrium, while if it be below the centre of gravity the body is in unstable equilibrium.

Meta Compounds (*Chem.*) The prefix "meta" is used in three distinct senses in chemical nomenclature. (1) There is a series of acids and salts distinguished by this prefix. The meta acids may be regarded as derived by the union of one molecule of the acid oxide with one molecule of water, and the meta salts are derived from these acids. Examples: Metaboric acid, $B_2O_3 + H_2O = 2HBO_2$. Metarsenites (acid unknown), $As_2O_3 + K_2O = 2KAsO_2$. Metasilicic acid, $SiO_2 + H_2O = H_2SiO_3$. Metaphosphoric acid, $P_2O_5 + H_2O = H_2P_2O_6$. Metaperiodates, $I_2O_7 + K_2O = 2KIO_4$. (2) There are many substances which undergo polymerisation, and the prefix meta is applied to the polymer of unknown molecular weight or whose molecular weight was unknown when the name was given. Examples:

Metastannic acid, $H_{10}Sn_5O_{15}$.	Polymer of stannic acid, H_2SnO_3.
Metaldehyde, $(C_2H_4O)x$.	Polymer of aldehyde, C_2H_4O.
Metastyrol, $(C_8H_8)x$.	Polymer of styrol, C_8H_8.

(3) The prefix is given to benzene derivatives when the substituents have replaced hydrogen atoms which are next but one to each other. For example *see* BENZENE.

Metal (*Glass Manufac.*) The name given to molten glass.

—— (*Plumb.*) In plumbers' work this term signifies solder.

—— *See* METALLURGY *and* METALS.

Metal Arches (*Civil Eng.*) Arches built up of iron or steel girders and lattice work, instead of solid stone blocks. As the members of such a structure can withstand tension as well as pressure, the structure can be modified to suit a greater variety of circumstances than stone bridges can.

Metaldehyde (*Chem.*) *See* ACETALDEHYDE.

Metal Furniture (*Typog.*) Furniture composed of an alloy. It gives truer register and is more economical than wooden furniture, and is now used extensively. *See* FURNITURE (*Typog.*)

Metal Leaf (*Dec.*) A term used for imitation leaf gold consisting of an alloy beaten out and sold in the same size sheets as gold leaf (*q.v.*) The term is also employed to include silver leaf, aluminium leaf, nickel leaf, and other leaf metal employed by gilders on glass and for decorative purposes generally.

Metallic Circuit (*Elect. Eng.*) A circuit composed entirely of metal conductors (*e.g.* wires) as distinguished from one in which the return path of the current is through the earth.

Metalliferous Veins (*Geol.*) Clefts or fissures in the Earth's crust which contain one or more of the ores of the metals, usually in association with other mineral substances of a non-metalliferous character, such as Quartz, Calcite, Barytes, and Fluor. The vein fissures are generally coincident with faults or lines of fracture, which appear to have formed the channels by which thermal or other waters containing these substances in solution have risen in the direction of the surface, and have left these substances when their depositing temperatures have been reached. The ores are most commonly compounds of the metals with Sulphur; but Arsenic, Antimony, or Bismuth may also be present. In rarer cases the metals may be combined with Tellurium. Near the surface of metalliferous veins carbonates and various oxygenated compounds usually occur. *See also* MINING.

Metallisation (*Elect. Eng.*) Covering a non-conductor with a film or coating of metal in order to impart electrical conductivity. Often used in electroplating non-metallic objects.

Metallography. The examination of prepared surfaces of metals under the microscope is of comparatively recent growth, for the first work in this direction was done by Dr. Sorby, of Sheffield, about 1864. It closely resembles the microscopic study of rocks, and was probably suggested by the examination of metallic meteorites in a similar manner. Rock sections are usually thin enough to be examined by transmitted light; but metallic sections are opaque, and reflected light must be used for their examination. A small piece of the metallic body is so cut as to form a fair sample of the whole. This is ground and polished to a flat surface, free from microscopic scratches. The structure is then brought out by immersing the surface in an etching liquid, by heating in air, or by a final polishing on a soft bed. The object of this treatment is to bring about a differential attack upon the structural constituents of the surface, and so render them visible under the microscope. Many such constituents are so identified in iron and steel, and in alloys of copper, tin, lead, zinc, antimony, etc. Several constituents of steel, in the different states of the metal brought about by heat treatment, combined with sudden and slow cooling, have been recognised. The principal of these are ferrite, pearlite, sorbite, and troostite. The different constituents, when viewed under the microscope, present very characteristic appearances; and the sections can be preserved for future examination by a thin coat of transparent varnish, or a photomicrograph can be taken and a permanent record thus obtained. The magnifications used are from 25 to 2,000 diameters. By work of this kind the crystalline character of metals in their normal state has been clearly brought out, and much information about the effects of mechanical stresses, of annealing, and of impurities upon the structure and properties of metals has been obtained. The similarity of quenched steel to a solid solution has been proved, and the assimilation of solid solutions to liquid solutions indicated. The subject is gradually growing in importance, and among its many workers are to be found the names of such men as Martens, Osmond, Stead, Roberts-Austen, Charpy, Heycock, and Neville.

Metalloid (*Chem.*) A name given to a few elements which may be regarded as sharing the properties of a metal and a non-metal. Thus antimony forms a gaseous hydride, SbH_3; two acid oxides, Sb_2O_3 and Sb_2O_5, and resembles the non-metals in these respects; but it forms a chloride which behaves in most respects like a metallic chloride, and it forms a sulphate which no non-metal does, yet it forms no carbonate, phosphate, or nitrate, as most metals do. Tellurium is another metalloid. Arsenic is regarded by some as a metalloid, but chemically its behaviour is entirely non-metallic.

Metallurgy. Dr. Percy, who did so much for the systematic study of metallurgy in this country, defined it as "the art of extracting metals from their ores, and adapting them to the various purposes of manufacture." That the art was practised in very

early times is indicated by the references to metals and their uses in the oldest written records of the world's history. In fact, the ancient Egyptians and Hebrews were so skilled in the working of metals that the craft must have been in existence before the dawn of history. Metals are rarely found in the metallic state, but are usually combined with oxygen, sulphur, carbon, etc. These compounds are always mixed with more or less earthy matter, or "gangue," and together with it form the ores of the metals. Gold occurs in the metallic state in its ores. There are two main processes used in the smelting, or fire treatment, of ores for the extraction of their metals. These are *roasting* and *melting*. In the first, the material is heated in contact with air to a temperature below its fusing point, so that it remains solid during the operation. In the second, the material is melted either by itself or mixed with other materials necessary for the complete operation. This work is done in furnaces of various kinds, but belonging to two main types: (*a*) reverberatory furnaces, in which material to be heated is placed on a separate bed; and (*b*) shaft furnaces, in which the fuel for generating the heat is mixed with the materials to be heated. In addition to this heat treatment, some ores have to undergo the mechanical processes of crushing, grinding, and washing for the partial removal of earthy matter. Also some ores cannot be dealt with economically by the heat method, and their metals are extracted by the use of liquid agents; others, again, are best treated by a combination of the two methods. The extraction of iron from its ores was practised among the hill tribes of India at least three thousand years ago, and the ancient method is still in use there. Iron ore and charcoal are put into a small blast furnace, worked with goatskin bellows, and several hours are occupied in producing only as much iron as a man can carry in one hand. For a very long period little or no progress in iron smelting was made; but as the process migrated Westwards, the apparatus increased in size, and the output became larger. The next step was the extraction of the metal as cast iron, and the conversion of this material into wrought iron and steel by a separate process. This was followed by a considerable increase in the size of the furnaces. In 1806 a blast furnace in Staffordshire was making pig iron at the rate of 30 tons per week. Then came the introduction of the hot blast (1828), still larger furnaces, and a much increased output; but with the modern puddling process to cope with it. At the present time the Americans are leading in blast furnace practice. Working with a furnace 80 ft. high and 20 ft. in diameter, an output of 3,000 tons of pig iron per week is often obtained. The magnitude of this development will be understood when it is stated that about 8,000 tons of ore, flux, and fuel must be tipped into the top of the furnace, and 15,000 tons of air blown in at the bottom to produce this result. The accessory apparatus, such as blowing engines, hot blast stoves, and charging gear are large in proportion. The introduction of the Bessemer process (1855) for the conversion of molten pig iron into ingot iron and steel by blowing a strong blast of air through it caused a revolution in the iron and steel industry. The invention of the basic lining for the Bessemer vessel caused a further increase in its usefulness. With this apparatus 10 tons of pig iron can be converted into ingot iron or mild steel in twenty minutes. But this process has been largely displaced by the introduction of the Siemens open hearth, in which large quantities of similar metal are now being made. This furnace, which is of the reverberatory type, is worked with gaseous fuel, and its temperature is further increased by the use of the principle of regeneration also introduced by Siemens. The first furnaces in general use were of about 10 tons' capacity, and the development of the process is mostly in the direction of larger furnaces. Fixed furnaces of 40 and 50 tons' capacity are now common, and tilting furnaces of the Wellman type of 200 tons' capacity are coming into use. It is in such furnaces that the Talbot steel making process is being put to the test of practical experience. On the other hand, the Bertrand-Thiel, or duplex hearth, process is carried out in fixed hearths, and is in successful, though limited, operation. Another development is in the use of the combustible part of the waste gas from the blast furnace, which is produced in enormous quantities, for working gas-engines, instead of for raising steam. This has made greater headway in Germany than in this country. The magnetic separation of finely divided ore, by which the iron compound is separated from the earthy matter, is now largely practised. Much attention has been given of late years to the production of sound ingots. In the latest modification Hamet, of St. Etienne, introduces the pressure at the bottom of the mould instead of at the top, and with considerable success. Electrical appliances are coming into general use; and electric smelting of iron and steel is making some headway where water power is cheap. In the metallurgy of copper considerable advance has been made of late years. The Welsh process, which was carried out entirely in reverberatory furnaces, was the principal method of extraction when Swansea was the chief copper smelting district of the world. Now many modifications have been introduced; the water jacketed blast furnace for the production of coarse mattes, and the Bessemer converter for fine mattes and coarse copper, are largely used. Even the refining of copper is being carried on electrolytically when gold, silver, or nickel is present in the crude metal. The furnaces for roasting pyritic ores and mattes have been much improved, and mechanical furnaces are taking the place of hand worked ones. The White-Howell, in which the finely divided ore is fed in at one end of a revolving cylinder, through which hot gases and air are passing and delivered at the other end, is an illustration of this change. The winning of gold from its ores has been helped by the introduction of the cyanide method of extraction. This was first used in South Africa, but has now found its way to America and Australia. It depends upon the fact that a weak solution of potassium cyanide will dissolve finely divided gold, and that gold can be precipitated from the solution by zinc. It is largely used in the treatment of slimes which have already been through the amalgamation process. At the Homestake Mine, Dacotah, 1,250 tons are treated daily. The gold reduced from the solution by the zinc is collected in a filter press, and allowed to accumulate until a cake about a ton in weight, and worth £10,000, is obtained; this is then refined by cupellation. Seventy-five per cent. of the assay value of the slimes is recovered at a cost of 1*s*. 6*d*. per ton of slimes. The Indian gold industry has benefited by its introduction, and it has solved the difficulty of dealing with telluride ores of gold in Western Australia. The extraction of other metals has been considerably influenced by modern improvements in furnace construction and working. This is so in the case of zinc, mercury, tin, etc., and the old wet

method of nickel extraction has disappeared. The use of the blast furnace in dealing with complex lead ores containing silver has considerably reduced the price of the latter metal. Ancient metallurgy was the father of chemistry, but modern metallurgy owes much to the exact processes of modern chemistry.—J. H. S. *See also* MINING.

Metal Patterns. Patterns made of brass, tin, lead, or (more commonly) of iron. *See* IRON PATTERN.

Metal, Road (*Civil Eng.*) *See* ROAD METAL.

Metal Rule (*Typog.*) A general expression for the rule by means of which plain, dotted, wavy, or other lines are produced in printing—em rules or dashes, thus –, —, ——.

Metals. Solid elements, with the single exception of mercury, which is a liquid, which (*a*) form basic oxides, (*b*) form chlorides which are in most cases not decomposed by water, and in the few cases in which they are decomposed by water give basic chlorides; (*c*) either form no compound with hydrogen or, when they do, give a solid compound, while all non-metals form at least one hydrogen compound which is gaseous. Any typical metal will conform to all these requirements; but in one or two cases the requirements are not completely conformed to, as, for instance, in the case of antimony, which forms a gaseous hydride, but conforms in other respects: antimony may be called a metalloid (*q.v.*) Besides the chemical distinctions just mentioned, there are certain physical properties which distinguish the metals as a class from the non-metals as a class; but if these are applied to particular cases they often break down. For example, the density of the metals as a class is higher than that of the non-metals as a class; but the metal lithium has a density of 0·6, while the non-metal iodine has a density 5·0. The physical properties referred to are density, malleability, ductility, electrical and thermal conductivity. As a class the metals possess these properties in a higher degree than the non-metals as a class; but the metals show great differences among themselves in these properties. Lithium, the lightest metal, has a density of 0·6, while osmium, the heaviest metal, has a density of 22·5. Pressure increases the density up to 10,000 atmospheres, and above this up to 150,000 atmospheres diminishes it—the explanation of this surprising result being that a metal contains solid and liquid molecules the former of which are incompressible, but at excessive pressure change to the latter and increase in volume in doing so. In malleability metals differ enormously, gold, silver, and copper being the most malleable; gold, silver, and platinum the most ductile; while bismuth is neither malleable nor ductile. In conductivity, both electrical and thermal, similar wide differences exist; thus, the former value for copper being 100, silver, the best conductor, is 105, and mercury is 1·6; the latter value for silver being 100, copper is 73·6, and mercury is 1·3. The melting points of the metals also vary greatly: mercury melts at −39·4°, silver at 961°, copper at 1080°, platinum at about 1780°, chromium about 2000°, while osmium is practically infusible. Many metals are transparent to light in thin films: gold leaf transmits green light; mercury, blue light; silver, blue light. Most metals appear to have monatomic molecules (*q.v.*); this has been ascertained by the lowering of the freezing points of solutions of the metals in tin.

Metals (*Civil Eng.*) The rails of a railway.

—— (*Her.*) There are two metals used in heraldry —gold and silver blazoned *or* and *argent*. *See under* HERALDRY.

Metal Spinning (*Eng., etc.*) Many circular objects may be formed out of sheet metal by means of a process termed spinning. A flat sheet of metal is cut approximately to size, and mounted on a chuck whose cross-section follows the profile of the object to be formed. The chuck is set in rotation in a lathe, and a smooth blunt-ended tool is pressed against the metal, which is gradually caused to conform to the outline of the mould formed by the chuck. The process can be applied to almost any malleable metal, and is frequently used in forming circular bowls, dishes, etc., of pewter, Britannia metal, copper, and brass.

Metamerism (*Chem.*) *See* ISOMERISM.

Metamorphic Rocks (*Geol.*) Sedimentary or else eruptive rocks which have undergone changes within the Earth's crust, by which their original character has been more or less altered. This may arise through the prolonged action of heated waters without any accompanying effect of a mechanical nature (thermometamorphism). Of this nature are many marbles and quartzites, and all kinds of hornfels. It may be due to causes of a dynamical kind, as in the case of the conversion of sediments into Muscovite Schist; or, lastly, it may arise simply through the chemical action of subterranean waters at a low temperature.

Metamorphism (*Geol.*) A general term used by geologists in connection with rocks of any kind that have undergone changes since their formation which have altered their general aspect. It is usual to recognise three types: (1) The changes induced in rocks by the prolonged action of heat in the presence of water. This is distinguished as thermometamorphism. (2) The effects arising from movements within the Earth's crust, especially from those connected with important changes of level at the surface. These are referred to as dynamic metamorphism. (3) The effects of the prolonged action of underground waters. The last is known as hydrometamorphism.

Metaphosphates (*Chem.*) Salts of metaphosphoric acid. *See* PHOSPHORUS COMPOUNDS.

Meteor (*Astron.*) A small body which becomes incandescent in passing into the Earth's atmosphere, and is burnt up before it reaches the Earth's surface. There are numerous showers of meteors, the more important being those that occur in August and November each year.

Meteorites (*Astron.*) Stony or metallic bodies of various sizes which fall on the Earth's surface from outer space. In passing through the air they become fusible, and sometimes burst with a loud explosion. They are usually classed, according to their composition, as: (1) Stony meteorites or aërolites, which are closely related to some of the ultrabasic eruptive rocks. (2) Siderites, which consist largely of alloys of iron and nickel.

Meteoritic Hypothesis (*Astron.*) An hypothesis which suggests that all the heavenly bodies are either meteoric swarms, more or less condensed, or the final products of such condensation.

Meteorograph (*Meteorol.*) An instrument generally attached to kites for obtaining the combined records of the thermometer, barometer, anemometer, and relative humidity.

Meteorology. Meteorology is the science which treats of the condition of the atmosphere surrounding our earth and the causes which give rise to the manifold variations of temperature, etc. The subject may be divided into WEATHER and CLIMATE. WEATHER may be regarded as one phase in the succession of phenomena whose complete cycle, recurring with more or less uniformity every year (*see below*), constitutes the climate of any place. CLIMATE is, therefore, the sum total of the weather, and gives us an idea of the *average* conditions of the atmosphere on different parts of the earth's surface. The earth with its surrounding envelope of air being a satellite of the sun, a body relatively very hot and of immense size, it is only natural that this central orb should be the all-dominating factor in terrestrial atmospheric changes and movements. This envelope is heated indirectly by the solar rays, the earth being warmed first and then parting with its heat to the air in contact with it. A circulation is thus set up, the warm air rising, and its place being filled up by the inflow of cooler air. This ascent of warm air reduces the atmospheric pressure at the locality in which it occurs, and thus a cyclonic region is initiated. Low pressures therefore are associated with ascending air currents. Since the air in these ascending currents cools as it reaches higher regions of the atmosphere, it must necessarily descend again to the earth. Regions where these descents occur are localities of high pressure (anticyclonic areas). The earth being unequally heated by the solar rays, the equatorial regions receiving more heat than the poles, there is a tendency for an interchange of air between these localities. What is the exact manner of this interchange is a question as yet under investigation; but it is shown to be incorrect to say that "polar" and "equatorial" currents, as usually defined, occur. Nevertheless, the earth, with the cold regions at the poles and the highly heated equator, may be considered as a huge condenser. Two facts which tend to complicate the atmospheric circulation are: (*a*) That land surface is more easily heated and more quickly cooled than water surface; and (*b*) that the distribution of land and water is very unequal, the northern hemisphere having by far the greater predominance of land. Again, the earth is not a stationary body relative to the sun, but moves, revolving round it once a year, and at the same time spinning on its axis in a period of a day. The first result of this latter motion is that the general circulation towards and away from the equator does not take place in a north or south direction, but the direction of movement is deviated to the right of the original direction. Again, since only one-half of the earth can be turned towards the sun at any one moment, the other half being in darkness and shielded from the heat rays of the sun, an unequal heating of the atmosphere as a whole is set up. This results in the "diurnal variations" of the meteorological elements, such as pressure, temperature, etc. These elements have also an annual variation, due to the revolution of the earth round the sun. In consequence of the inclination of the earth's axis to the plane of the ecliptic—*i.e.* the plane in which the earth moves—sometimes the northern hemisphere and sometimes the southern hemisphere is more exposed to the solar rays. This is the cause of the variations known as "seasonal changes." In consequence of these two periodic movements of the earth, and the resulting variations in the intensity and direction of the air currents, we have changes of WEATHER. The greater the distance from the equator the more complex do these changes become, owing to the interlacing currents producing rapidly moving cyclonic and anticyclonic areas. Now, if the sun gave out the same quantity of heat each year, more would probably be known about the laws of such changes. Although direct measurements of the quantity of heat radiated do not indicate solar variations of heat, there are periodic changes in solar phenomena, such as spots, prominences, and coronal streamers, which show great disturbances in the solar atmosphere. These disturbances are periodic in their nature, so far as can at present be determined, and have periods of about four, eleven, and thirty-five years. There is thus reason to believe that the sun does change its temperature, and such variations should have its effect on the terrestrial atmospheric circulation. WEATHER, therefore, will be subject to continual changes, and so will the CLIMATE of any region. That all countries are subject to series of wet and dry years, with their attendant disastrous floods and droughts respectively, is a fact well known, and it is the aim of METEOROLOGY to investigate, and possibly ultimately discover, the laws by which these variations are governed.—W. J. S. L.

Meter (*Build.*) An apparatus for measuring the volume of gas or water supplied to a building, etc.

—— (*Elect. Eng.*) A device for measuring the amount of energy—usually in WATT HOURS (*q.v.*)—supplied. A meter usually contains mechanism actuated or controlled by the current; this mechanism registers the supply by means of dials. In most cases, as the voltage is constant, only the number of ampère hours is recorded, one ampère hour being the quantity of electricity which is transferred by a current of one ampère flowing for one hour. There are very many types of meter; the following may be taken as examples. The ARON METER contains two trains of clockwork, each governed by a pendulum. One pendulum swings under the action of gravity only; the other carries a permanent magnet as a bob. Underneath this magnet a solenoid is fixed, through which the current passes. An additional controlling force is therefore experienced by the second pendulum, which causes it to swing quicker than the first. The number of beats which the second pendulum gains in a given time depends upon the strength of the current (other things being equal); by means of suitable mechanism this number is registered, and the number of ampère hours read off on dials. The EDISON METER depends upon the principle of electrolysis (*q.v.*), and registers the quantity of current which has passed by means of the decomposition of a solution of zinc sulphate with zinc electrodes. The loss in weight of the anode should equal the gain in weight of the cathode, and each is proportional to the total quantity of electricity which has flowed through the electrolytic cell. The SHALLENBERGER and ELIHU THOMPSON METERS are types in which the mechanism is rotated by the current at a rate which is proportional to the current whose strength is to be recorded. The former is adapted for the measurement of alternating currents at constant voltage; the latter can be used on either alternating or direct current circuits, and gives the number of watt hours directly, whether the voltage vary or not.

Methane (*Chem.*) CH_4. *Also called* **Marsh Gas, Light Carburetted Hydrogen,** *and, by coal miners,* **Firedamp.** A colourless, odourless gas; boils at $-156°$, solidifies at $-184°$. It is a light gas, very

sparingly soluble in water. It burns in air with a feebly luminous flame to carbon dioxide and water, $CH_4 + 2O_2 = CO_2 + 2H_2O$. A mixture of methane with twice its volume of oxygen—the proportions required by the above equation—or ten times its volume of air, explodes violently when ignited. When slowly burned with insufficient oxygen (two volumes marsh gas to one volume oxygen) it forms formaldehyde, carbon monoxide, carbon dioxide, and steam.

$$\begin{array}{c}H\\|\\H-C-H\\|\\H\end{array} + O_2 = \begin{array}{c}H\\|\\H-C=O\end{array} + H_2O, \begin{array}{c}H\\|\\H-C=O\end{array} + O_2 = CO_2 + H_2O$$

$$2\begin{array}{c}H\\|\\H-C=O\end{array} + O_2 = 2CO + 2H_2O$$

Chlorine in bright sunlight decomposes it, giving carbon and hydrochloric acid. But when the action is slower substitution occurs, giving methyl chloride, CH_3Cl; methylene chloride, CH_2Cl_2; chloroform, $CHCl_3$; and carbon tetrachloride, CCl_4. It occurs when vegetable matter decomposes in contact with water, so that it arises in bubbles from stagnant pools, and it is found in coal. Its presence in coal mines is sometimes the cause of explosions. It also occurs in the gases from oil wells. Methane is synthesised by passing carbon monoxide or dioxide and hydrogen over finely divided nickel at 300°. Ordinarily it is prepared by heating a mixture of sodium acetate and soda lime, $\begin{array}{c}CH_3\\|\\COONa\end{array} + HONa = CH_4 + CO(ONa)_2$.

Very pure methane is obtained by the action of zinc coated with copper on a mixture of methyl iodide and methyl alcohol,

$$CH_3I + CH_3OH + Zn = CH_4 + Zn\left<\begin{array}{l}CH_3\\I\end{array}\right.;$$

but the gas so prepared must be passed through a tube immersed in a powerful freezing mixture to remove vapour of methyl iodide.

Methoxides (*Chem.*) Compounds derived from methyl alcohol by the replacement of the hydroxyl hydrogen by metals; *e.g.* sodium evolves hydrogen when it is brought into methyl alcohol, and forms sodium methoxide, $CH_3OH + Na = CH_3ONa + H$. This is the most important methoxide; it is a white crystalline solid, soluble in methyl alcohol, and easily decomposed by water, $CH_3ONa + H_2O = CH_3OH + NaOH$.

Methoxy (*Chem.*) The name given to the group CH_3O-. This group has no independent existence, but this name for the group enters largely into chemical nomenclature; *e.g.* several alkaloids contain methoxy groups (codeine, *see under* MORPHINE; quinine, *see under* CINCHONINE). The methyl group in methoxy compounds is replaced by hydrogen by the action of hydriodic acid. The hydroxy group (—OH) in a phenol is converted into the methoxy group by the action of methyl iodide and sodium ethoxide. *See under* MORPHINE.

Methven Screen. An opaque screen containing a narrow slot, placed in front of a standard gas burner; the size of the slot is so adjusted that the light transmitted shall be equal to that of two standard sperm candles, when the gas flame is 3 in. high. Its value depends upon the fact that the luminosity is proportional to the height of the flame rather than the quality of the gas, within very wide limits. It is used as a standard light in photometric work.

Methyl (*Chem.*) The name given to the group CH_3-. This group has no independent existence, but this name for the group enters largely into chemical nomenclature; *e.g.* CH_3Cl is called methyl chloride; $C_6H_5NHCH_3$ is called methyl aniline, because it may be regarded as aniline, $C_6H_5NH_2$, in which one atom of hydrogen in the NH_2 group has been replaced by the methyl group.

Methylal (*Chem.*), $CH_2\left<\begin{array}{l}OCH_3\\OCH_3\end{array}\right.$. Pleasant smelling liquid; boils at 42°; soluble in water. Formed by oxidation of methyl alcohol with manganese dioxide and dilute sulphuric acid.

Methyl Alcohol (*Chem.*), CH_3OH. (The crude alcohol is called wood spirit and wood naphtha.) A colourless liquid; smells like ethyl alcohol; boils at 66°; soluble in water: burns with blue flame to carbon dioxide and water. Its chemical reactions are like those of ethyl alcohol. With sodium it gives sodium methoxide, CH_3ONa; with the chloride of phosphorus, methyl chloride, $3CH_3OH + PCl_3 = 3CH_3Cl + H_3PO_3$; it forms a crystalline solid with calcium chloride, $CaCl_2 4CH_3OH$; on gentle oxidation it forms formaldehyde (*q.v.*); with acids usually in presence of a dehydrating agent it forms esters, *e.g.* $CH_3OH + HCl = CH_3Cl + H_2O$. It occurs combined with salicylic acid in oil of wintergreen, and can be obtained from this by boiling in a flask with reflux condenser with caustic soda solution, then distilling the product. Only methyl alcohol and water distil over

$$C_6H_4\left<\begin{array}{l}OH\\COOCH_3\end{array}\right. + NaOH = \underset{\text{Sodium salicylate.}}{C_6H_4\left<\begin{array}{l}OH\\COO\ Na\end{array}\right.} + CH_3OH$$

On the large scale it is obtained from the watery portion of the distillate from the distillation of wood in closed vessels. This watery portion is called pyroligneous acid. About a tenth is distilled over, and the distillate is mixed with slaked lime and redistilled. This removes acetic and other acids. It is now distilled from a little sulphuric acid: this removes bases. This distillate is stood over quicklime and again distilled—removal of water. This product is crude wood spirit; it contains acetone and other impurities. Calcium chloride is now added to form the crystalline compound mentioned above, which is filtered off and pressed, treated with water, and distilled; methyl alcohol and water pass over. The alcohol is dehydrated over quicklime as before.

Methylamine (*Chem.*), CH_3NH_2. Gas, colourless; smells like ammonia and fish at the same time; boils at −6°; extremely soluble in water (1,150 volumes in 1 volume of water at 12·5°); readily burns in air with a yellow flame, forming carbon dioxide, water, and nitrogen. It is a powerful base, forming salts with acids, just as ammonia does, and its aqueous solution gives precipitates of the hydroxide with solutions of metallic salts, also like ammonia does; but with nitrous acid it yields methyl alcohol.

$$CH_3NH_2 + ON.OH = CH_3OH + N_2 + H_2O$$
$$NH_3 + ON.OH = H_2O + N_2 + H_2O$$

With methyl iodide it forms dimethylamine hydriodide, then trimethylamine hydriodide, then tetramethylammonium iodide. It unites with ethyl oxalate to form dimethyloxamide. *See* TRIMETHYLAMINE. It occurs in herring brine, in pyroligneous acid (*see* METHYL ALCOHOL), in the plant Dog's Mercury (*Mercurialis perennis*). It is best obtained from acetamide by dissolving in

bromine, adding 10 per cent. caustic potash solution till yellow, and distilling the product with 20 per cent. caustic potash. The distillate must be received in hydrochloric acid. Some ammonia comes over with the methylamine. To separate the two hydrochlorides evaporate to dryness on a water bath, and treat with absolute alcohol, when methylamine hydrochloride alone dissolves; filter and evaporate; the base may be set free by caustic soda. It is also produced by the reduction of hydrocyanic acid with zinc and sulphuric acid, by the reduction of nitromethane with iron fillings and acetic acid, by distilling glycocoll (*q.v.*) with baryta.

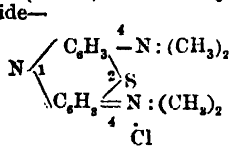
Methylated Spirit (*Chem.*) A mixture of 90 per cent. raw spirit of wine (crude ethyl alcohol) and 10 per cent. wood spirit (crude methyl alcohol), to which some paraffin oil has been added. This concoction can be used for many technical and chemical processes, instead of pure alcohol, and as it is not drinkable it is sold free of duty. It is used as a solvent, for burning, and for the manufacture of "methylated" ether and "methylated" chloroform.

Methylates (*Chem.*) *See* METHOXIDES.

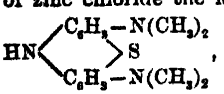
Methyl Chloride, Bromide, *and* **Iodide** (*Chem.*), CH_3Cl, CH_3Br, and CH_3I. The first two are gases which boil at $-24°$ and $4·5°$ respectively; the third, is a liquid which boils at 43°. In properties, reactions, and preparation they resemble the corresponding ethyl compounds. *See these.* The chloride is used in medicine as a local anæsthetic, and the iodide is an important reagent in organic chemistry, just as ethyl iodide is.

Methylene (*Chem.*) The name given to the group $\overset{|}{\underset{|}{CH_2}}$, which has not an independent existence. Examples of methylene derivatives are methylene iodide, CH_2I_2; hexamethylene, $CH_2\left<\begin{smallmatrix}CH_2-CH_2\\CH_2-CH_2\end{smallmatrix}\right>CH_2$, etc. Methylene iodide is a heavy colourless liquid (specific gravity, 3·34), obtained by reduction of iodoform with hydriodic acid.

Methylene Blue (*Chem.*) Tetramethylamidophenthiazimium chloride—



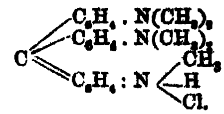
Dark blue powder, soluble in water and alcohol; dyes cotton mordanted with tannin a blue which is fast to light. Used in medicine for malaria, etc.; it colours the urine and fæces blue. It is obtained by oxidation of dimethylparaphenylenediamine in presence of sodium thiosulphate and further oxidation of the product by chromic acid in presence of dimethylaniline. On now boiling with a solution of zinc chloride the leuco-base is obtained



, which on oxidation yields the dye. The commercial dye is the zinc double salt $2(C_{16}H_{18}N_3SCl) . ZnCl_2 . H_2O$. *See* DYES AND DYEING.

Methyl Orange (*Chem.*) (*Also called* **Orange III., Helianthine, Tropæoline D.**) It is the sodium salt of paradimethylamidobenzene sulphonic acid (the free acid is sometimes called Helianthine). A yellowish red powder, soluble in water, giving a yellow solution when diluted. With acids the solution turns pink; on neutralisation of the solution the yellow colour is restored. *See* INDICATORS. It is prepared by the action of dimethyl aniline on the hydrochloride of diazobenzene sulphonic acid; on addition of caustic soda and common salt, methyl orange separates out.

Methyl Violet (*Chem.*),



Is a mixture of the hydrochlorides of penta- and hexamethylpararosaniline. *See* PARAROSANILINE. The above is the formula for the pentamethyl compound. It forms a lustrous green amorphous powder, soluble in water and in alcohol. It dyes silk and wool directly, cotton after mordanting with tannin and tartar emetic. It is prepared by oxidation of dimethylaniline in presence of phenol by means of cupric chloride (common salt and copper sulphate) at a temperature not above 60°; the solution in water is then treated with milk of lime, washed, suspended in water, and the copper precipitated by sulphuretted hydrogen. The base is extracted with warm hydrochloric acid, and precipitated by addition of common salt. *See* DYES AND DYEING.

Metol (*Photo.*) This—one of the newer substances introduced as a developer—is the sulphate of methylpara-amidometacresol, $C_6H_3CH_3OHNHCH_3 . SO_4$. It keeps well in solution with sodium sulphite, and is very energetic as a developer, giving negatives full of detail and good gradation. Combined with hydroquinone it is the favourite developer for the so-called gaslight papers.

Metonic Cycle (*Astron.*) A lunar cycle of 235 synodic months employed in finding the relation between solar and lunar years. Used for determining the time of Easter.

Metopes (*Architect.*) The square panels in the frieze of the Doric entablature separated by the triglyphs. The triglyphs are the constructive part of the frieze, the metopes being merely thin slabs either carved or left plain. In very ancient examples the spaces between the triglyphs were left open. *See* ENTABLATURE; ARCHITECTURE, ORDERS OF; *and* DORIC.

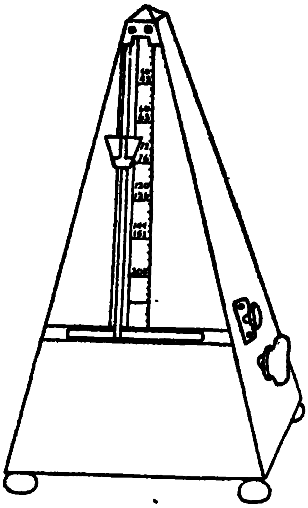
Metoquinone (*Photo.*) A compound formed by mixing saturated solutions of metol and hydroquinone in the proportion of two parts of metol to one of hydroquinone. Anhydrous soda sulphite is then added to saturation, when, after a few seconds, an abundant precipitate is obtained in the form of brilliant white particles. A formula for developments is as follows:

Metoquinone . . .	4 grains.
Anhydrous Soda Sulphite .	26 „
Water	1 oz.

Metre. The metre, which is the legal standard of length of the French Republic, was originally defined as one ten-millionth of the distance from the Pole to the Equator. It was thought that a natural standard of length could thus be obtained, but the difficulty of accurately comparing the metre with the chosen distance has proved so great that the length of a certain bar of platinum at 0° C. is now defined as the legal metre. The Earth's quadrant is (according to recent measurements) ten million eight hundred and eighty (10,000,880) metres. *See also* WEIGHTS AND MEASURES.

Metric System. *See* WEIGHTS AND MEASURES.

Metronome (*Music*). An instrument for measuring the relative length of notes and for enabling performers to ascertain the exact speed at which composers wish their works to be performed. It consists of an oscillatory steel rod (worked by clockwork action) suspended on a pivot with a fixed weight at the lower end, and a smaller and movable weight at the upper end, which by being placed nearer to the pivot increases the oscillations per minute. Behind the pendulum are figures to enable the proper adjustment of the weight to be made according to the directions on the musical composition to be timed. These directions consist of the letters M.M. (Maelzel's Metronome), and a note and figures, *e.g.* M.M. 𝅗𝅥 = 72. To ascertain this the top of the movable weight would be set at 72, and each oscillation of the pendulum would be the speed of the minims; in fact, the numbers show the number of beats per minute. Care must always be taken to see which length note is being timed (*e.g.* 𝅗𝅥 = 72 equals ♩ = 144) otherwise ridiculous mistakes will be the result. Another metronome (Pinfold's) oscillates on the finger.



MAELZEL'S METRONOME.

Mezzanine. An intermediate storey, frequently in a wing, between two storeys of the main building. The French name is ENTRESOL.

Mezzo (*Music*). Half.

Mezzo-Relievo (*Sculp.*) Sculpture in which the figures project half their true proportions from the background. *See* ALTO-RELIEVO, BASSO-RELIEVO, CAVO-RELIEVO, *and* INTAGLIO.

Mezzo-Soprano. The voice between soprano and contralto.

Mezzotint. *See* ENGRAVING (MEZZOTINT).

M.G. (*Music*). The left hand; the letters standing for the French *main gauche*. *See* M.S.

Mho (*Elect.*) A name (rarely used) for the unit of conductivity; it is equal to the conductivity of a conductor whose resistance is 1 ohm (*q.v.*) If the resistance of any conductor be *r* ohms, its conductivity is $\frac{1}{r}$ mhos.

Mi (*Music*). The Sol-Fa syllable for E.

Mica (*Elect.*) Mica is used (1) as an insulating material in cases where the latter is required in the form of thin plates; (2) as a dielectric material in condensers, on account of its high specific inductive capacity. *See* INSULATING MATERIALS *and* SPECIFIC INDUCTIVE CAPACITY.

—— (*Min.*) The name applied to a group of hydrous silicates crystallising in the monosymmetric system and showing pseudohexagonal forms. All have a perfect basal cleavage, the lamellæ being elastic. Usually transparent in thin lamellæ. *See* BIOTITE, MUSCOVITE, *etc.*

Micanite (*Elect. Eng.*) A non-conducting substance composed of small plates of mica cemented together by some non-conducting cement. It can be moulded into a variety of convenient forms.

Mica Trap (*Geol.*) *See* TRAP (*Geol.*)

Microbe (*Biol.*) A term loosely applied to certain minute organisms, especially those constituting the germs of diseases. *See* BACTERIA, BACILLI, MICROCOCCUS, SPIRILLUM, VIBRIO, *etc.*

Microcline (*Min.*) An aluminium and potassium polysilicate, $K_2O.Al_2O_3.6SiO_2$. Triclinic. It often shows a striping due to multiple twinning, and also a cording. Twinning also occurs in a simpler form. Usually white to flesh colour; but the variety Amazonstone is green. Of wide distribution as a rock forming mineral.

Micrococcus (*Biol.*) Bacteria having a short rounded form; they are found either isolated from each other, or in rows looking like a string of beads.

Microcosmic Salt (*Chem.*) A common name for sodium ammonium phosphate. *See* SODIUM COMPOUNDS.

Microfarad (*Elect.*) One millionth part of a FARAD (*q.v.*)

Micrometer. A general term for an instrument for measuring very small lengths. *See* MICROMETER GAUGE, MICROMETER EYEPIECE, SCREW GAUGE, *etc.*

—— (*Astron.*) In astronomical measurements various forms of micrometers are employed, such as the filar position micrometer, etc. They are used for measuring small angular distances in space.

Micrometer Eyepiece. An eyepiece used to microscopes, telescopes, etc., and furnished with a finely divided transparent scale, which is so placed as to be in focus at the same time as the image of the object which is viewed. The apparent size of the object or the relative sizes of its parts can be read off directly on the scale; the real size (in the case of a microscope) is found by placing a STAGE MICROMETER, which is another finely divided scale, in the place of the object, when the absolute value of the divisions of the scale in the eyepiece is at once evident.

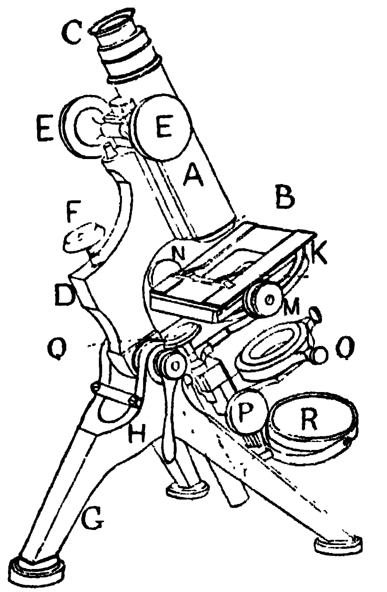
Micrometer Gauge (*Eng.*) A form of SCREW GAUGE (*q.v.*) made with jaws sufficiently wide to allow of its use as a caliper for measuring the external dimensions of objects with great accuracy.

Micro, Micr. A prefix denoting that the unit is divided by one million, *e.g.* MICROHM, one millionth of an ohm.

Micron. One millionth part of a metre.

Microphone (*Elect.*) An instrument used in the transmission of sound in a telephone circuit. It consists essentially of one or more loose contacts between conductors (usually pieces of carbon) forming part of the circuit. This loose contact is extremely sensitive, a very small vibration producing a variation in the resistance at the point of contact. If a battery and a telephone be joined in series (*q.v.*) with the pieces of carbon forming the loose contact, every vibration will cause a variation in the current, and therefore a movement of the diaphragm of the telephone and a corresponding sound in the latter. The TRANSMITTER of a modern telephone usually consists of some form of microphone; it is often termed a CARBON TRANSMITTER.

Microscope. The ordinary or COMPOUND MICROSCOPE consists of certain systems of lenses mounted in a tube or body, which is supported by a suitable stand provided with various devices for focussing, adjustment of the position of the object, concentration of light in the field of view, etc. It will be convenient to consider separately the optical and the mechanical portions of the instrument. The former comprises the OBJECTIVE, a combination of lenses, of short focal length, placed near the object to be viewed; it forms a real and considerably enlarged image of the object. A usual form of objective comprises three "double" lenses, each consisting of a double convex lens of crown glass cemented to a plano-concave lens of flint glass, the plane surface of each double lens being turned towards the object. The whole system is very carefully corrected for chromatic and spherical aberration. The equivalent focal length of the combination may vary from 3 in. down to $\frac{1}{16}$ in.; objectives of more than 1 in. focal length are, however, rarely used. For the higher powers (*i.e.* objectives of equivalent focus from $\frac{1}{8}$ in. downward) the optical properties of the objective may be greatly improved by filling the space between the cover glass of the slide and the lowest lens of the objective with some clear transparent liquid; water was originally used, but it is now customary to employ cedar wood oil, which possesses optical properties closely approaching those of glass (*i.e.* it has nearly the same refractive index and dispersive power). An objective intended for use in this manner is termed an OIL IMMERSION OBJECTIVE. The image formed by the objective is viewed by means of an EYEPIECE, which produces a virtual and enlarged image of the original (and real) image. The eyepiece usually consists of two lenses mounted in a short tube; in the form generally employed, known as the HUYGHENS EYEPIECE, the lenses are plano-convex: their focal lengths are in the ratio 3:1, and the distance between them is equal to the difference of the focal lengths. Other forms are also used, *e.g.* the RAMSDEN EYEPIECE (*q.v.*) A microscope is also fitted with a mirror, as shown at R in the figure; this serves to reflect light up through the slide. In most modern microscopes a plane and a concave mirror are fitted back to back in the same mount, so that either may be used at will. A CONDENSER is another device for the concentration of light. It may consist of a single convex lens placed on a separate stand, and arranged to focus a beam of light on the top of an opaque slide, or it may be some form of SUB-STAGE CONDENSER. This is a system of lenses (often provided with an adjustable diaphragm) fitted beneath the stage, *i.e.* between the mirror and the slide. In the figure the sub-stage O carries the condenser. A PETROLOGICAL MICROSCOPE is adapted for the examination of minerals by polarised light. A POLARISER (*q.v.*) is fitted to the sub-stage, and a NICOL PRISM (*q.v.*) fitted to an eyepiece serves as an analyser. *See also* POLARISATION. The mechanical arrangements of a microscope are shown in the figure, which is a somewhat diagrammatic representation of an instrument of Watson's Van Heurck model. A is the BODY, or tube, provided with a female screw at B, into which the objective is screwed; the eyepiece C slides into the top of the tube. The body is supported on the main frame D, and can be moved up and down by means of a COARSE ADJUSTMENT consisting of a rack and pinion, the latter being actuated by milled heads E, E. Accurate focussing is obtained by means of a fine threaded screw acting on the body through a lever and turned by a head F. The frame is supported by a strong claw foot G, and can be tilted and clamped at any angle by a locking nut furnished with a handle H. K is the STAGE. This can be completely rotated, while the upper part L, which carries the slide,



MICROSCOPE.

possesses linear traversing motion along two directions at right angles to each other, given by milled heads M and N. O is the SUB-STAGE, furnished with set screws for holding a condenser or polariser; it can be rotated in its support, and can also be raised or lowered by means of a coarse adjustment P and a fine adjustment Q. The illuminating mirror is shown at R. When two or more objectives have to be used in succession, it is convenient to fix them to a NOSEPIECE, a device attached at B. This enables either objective to be brought into position by means of a pivoted arm.

Microscope, Commercial Uses of. In addition to the purely scientific use made of the microscope, there is an extensive field for its continual employment in commercial circles and in industrial manufactures. There is scarcely any industry of importance in which the microscope does not play a prominent part. In the manufacture of IRON AND STEEL it is constantly resorted to in order to test and control the quality of finished goods, such as girders, boiler plates, and other steel structures in which strength and uniformity of material are of the utmost importance. Researches with the microscope have shown that very minute flaws in the material may lead to serious defects in steel structures, and steel being now so largely employed in buildings, it is evidently of the greatest importance that there should be some means of detecting flaws or defects in the metal. The manufacture of METAL ALLOYS also demands a continual reference to the microscope, as it is possible to measure the value and composition of an alloy by its appearance under the microscope. It also serves to determine very largely the physical changes due to the mixture of one metal with another, and whether the alloy is

homogeneous. It further affords a means of indicating the nature of the alloy produced, both as to structure and composition. In the ENGINEERING INDUSTRY the microscope finds employment for measuring minute differences in dimensions. Thus in the construction of instruments in which small alterations of length have to be measured with great accuracy, the microscope is the only satisfactory instrument for determining such differences. For example, it may be necessary to determine the actual alteration in length of a metal bar produced by an increase in temperature. The increase in length produced by a rise in temperature is, of course, a very small quantity, but the ratio of expansion is readily and accurately determined by means of the microscope. The sizes of flaws in metal, or of minute holes, are all exactly measured in this way. In the TEXTILE AND ALLIED INDUSTRIES the microscope is as essential for efficient and economical work as any other appliance in the factory. Thus in woollen industry the examination of raw materials can only be properly carried out with the microscope, and by its aid it is easy to determine the nature of the various wools used. The microscopical appearance of wools from sheep, goats, and other animals are all capable of classification, so that the manufacturer can readily determine the composition of the woollen goods which may come under his notice. The cultivators of silk, as well as the manufacturers, employ the microscope for ascertaining quality of thread, dimensions of the thread, and other factors. In the allied industries of ROPEMAKING, HAT MANUFACTURE, PULP AND PAPER INDUSTRIES, all of which trades depend on vegetable or animal fibres as their staple raw material, the microscope is relied upon as the instrument for a proper examination of not only the raw products, but more particularly the finished goods. The manufacturer is enabled by its means to examine the finished goods of his competitor in order to determine the materials used in the manufacture of such articles. In the matter of the raw material the microscope is not so essential as with the finished goods, because before treatment the raw material has marked physical differences visible to the eye. Thus in the case of paper the raw materials employed may be rags, hemp, jute, wood pulp, or esparto. In the raw condition these cannot be mistaken, but it is afterwards somewhat difficult to say what a given paper is made of by a mere inspection of a sample. The microscope is also largely employed in BREWING and BAKING in controlling the condition of the ferments necessary for the business. By this means they can be watched and used at the right time and to the fullest advantage. The makers and users of STARCH, FLOUR, MEAL, and similar products are also indebted to the microscope as a means for determining their nature, origin, and commercial value. It is interesting to note that the well known "Hovis" flour was the result of a careful microscopic investigation by Mr. Richard Smith. The examination of MILK, BUTTER, and other products of this kind by means of the microscope has thrown a great deal of light upon the necessity for absolute cleanliness and up-to-date methods in the handling of such perishable goods, and this industry can no longer be carried on in a haphazard manner; in fact, the preparation of almost every kind of foodstuff is controlled by means of the microscope. The examination of fruits, jams, and tinned goods are only a few other instances. The CHEMIST AND DRUGGIST determines the purity or otherwise of his drugs in a similar manner. The MEDICAL OFFICER OF HEALTH finds the microscope indispensable for the detection of adulteration in samples of food and the many hundreds of articles sold for domestic use. Without the microscope the purity of water and its freedom from bacteriological germs could not be ascertained, and the microscope is continually at work in this direction. The examination of SEEDS for farmers, florists, and fodder growers by means of the microscope is now a process of common and daily use. The suitability of STONES as material for BUILDING, the MAKING OF ROADS, etc., can also be determined by means of the microscope, thin sections of the various materials being prepared for examination. In detecting CRIME the microscope has long played an important part. Without it HANDWRITING EXPERTS would be almost helpless, for it enables them to determine very minute alterations in writing, differences in the nature of the ink employed, and any erasures upon the surface of the paper. In this way the microscope is a valuable adjunct to the art of photography. Finally, the value of the microscope for the examination of bloodstains and the detection of crime is now well known to the readers of the daily papers. *See* METALLOGRAPHY.

Mid *or* **Middle Gear** (*Eng.*) *See* LINK MOTION.

Midden *or* **Privy System** (*Hygiene*). This system, which at one time was largely prevalent in this country, but is now mainly confined to the northern and midland districts, aims at the deodorisation and drying of the excreta by admixture with ashes. Formerly the receptacles were mere holes in the ground, and their contents overflowed or percolated into the soil, thus poisoning the water in neighbouring wells. At the present day middens must be constructed according to certain definite rules. A model byelaw of the Local Government Board prescribes that a midden or privy shall be at least 6 ft. from any dwelling and 40 or 50 ft. from any well; the floor must be not less than 6 in. above the ground level, must be paved, and have an inclination towards the door of ½ in. to the foot. The capacity of the receptacle must not exceed 8 cubic ft., thus necessitating a weekly removal; it must be of impermeable material, not communicate with any drain or sewer, and have a hinged seat to admit of the application of ashes.

Middle C (*Music*). That note which stands on the middle line of the Great Stave of eleven lines, hence its position in the Treble and Bass Staves respectively as follows:

Middle Distance (*Art.*) That portion of a picture which is represented as lying between the foreground and the background.

Middle Oil (*Chem.*) That part of coal tar which distils between 170° and 230°. From it are obtained the important substances naphthalene (*q.v.*) and phenol (*q.v.*)

Middle Rail (*Elect. Eng.*) A heavy conductor in the form of a rail carried on insulating supports, which is laid between the running rails of an electric railway to supply current to the motors. Often termed the THIRD RAIL or LIVE RAIL.

Middle Rail (*Join.*) In framing, *e.g.* in a door or partition, the rail (*q.v.*) above the bottom rail.

Middling Spaces (*Typog.*) Spaces, used to divide words, four to an em of a particular body.

Midfeather (*Paper Manufac.*) A partition fixed in the "breaker" to promote circulation of the pulp.

Midfeather Trap (*Hygiene*). This consists of a round or square box, with an entry tube on one side and an outlet tube at an equal height on the other. A partition passes down between into the water, which stands up to the lower margin of each pipe. The trap is not self cleansing, and otherwise fails in all the essentials of a good trap.

Midnight Sun (*Astron.*) When the latitude of a place is greater than the polar distance of the sun or its co-declination, the sun will not set, but will make a complete circuit of the heavens. At midnight, therefore, the sun will be visible; hence the "midnight sun."

Migration of the Ions (*Elect.*) *See* IONS, MIGRATION OF.

Mil (*Elect. Eng., etc.*) The one-thousandth part of an inch. Used to denote the diameters of wires, thickness of transformer plates, etc., instead of the numbers in the WIRE GAUGE (*q.v.*), since it is more convenient in electrical calculations to have these measurements given at once in inches.

Mild Alkali. *See* ALKALI.

Mild Steel (*Eng.*) Steel which contains a low percentage of carbon; it resembles wrought iron very closely, and can be welded. *See* STEEL.

Mile. *See* WEIGHTS AND MEASURES.

Milk (*Foods*). Consists of casein (albuminoids), fat, carbohydrates, salts, and water, and thus contains all the constituents of a standard diet. Cow's milk contains more casein and salts and less carbohydrates than human milk, so that in employing it as a food for infants it is necessary to dilute it and add milk sugar. In the process of digestion the curd (casein and fat) of human milk forms a loose, flocculent mass, easily assimilated, whilst cow's milk clots in masses digested with difficulty. In the artificial rearing of infants this is remedied by the addition of barley water to the cow's milk. By Sec. 3 of the Sale of Foods and Drugs Act, 1879, an inspector may take a sample of milk for analysis which is consigned from one person to another. The sample must be taken at the place of delivery. Vendors of milk and cream must exhibit their name and address on the vehicle or receptacle from which the milk is sold (Sec. 9). Sec. 11 provides that condensed, separated, or skimmed milk shall not be sold, or exposed for sale, except in receptacles labelled so that the words are plainly visible to the purchaser. *See also* COW'S MILK, CURD OF MILK, *and* FOODS.

——, **Humanised** (*Foods*). Produced by the addition of cream and sugar of milk to sterilised cow's milk, thus supplying the deficiency of fat and sugar.

Milk of Lime (*Chem.*) *See* CALCIUM COMPOUNDS.

Milk of Sulphur (*Chem.*) *See* SULPHUR.

Milk, Pasteurised (*Foods*). When raised to a temperature of 180° F. milk is said to be Pasteurised.

——, **Sterilised** (*Foods*). Milk is sterilised, and thus preserved from fermentation and decomposition, by raising it to a temperature of 212° F. *See also* STERILISATION.

Milk Sugar (*Chem.*) *See* LACTOSE.*

Milky Way (*Astron.*) *See* GALAXY.

Mill. (1) A general term for a factory. (2) A machine (or set of machines) for grinding a substance.

Millboards (*Bind.*) The boards which are attached to the unbound book by "lacing in" (*q.v.*) When covered with leather, cloth, or other substance they form the covers of the book. Millboards are made from various materials, the best from old rope; the cheapest from straw, jute waste, etc.

Milled Head. The head of a screw provided with corrugations on its edge to enable it to be turned by the fingers; used on adjusting screws, etc.

Milled Lead (*Plumb.*) Sheet lead that has been rolled.

Millerite (*Min.*) Sulphide of nickel, NiS. Nickel = 64·9, sulphur = 35·1. Rhombohedral, usually in extremely fine, hairlike crystals; hence the name HAIR PYRITES. Brassy yellow when fresh. Found in several localities in the British Isles sparingly, especially in Cornwall and Devon; also in Bohemia, Saxony, and the United States.

Millet (*Botany*). Various species of millet, *Pennisetum typhoideum* (order, *Gramineæ*), are important food plants in India, Egypt, and West Africa. *See also* DHURRA.

Milli-. A prefix to the name of a unit, denoting that the unit is divided by one thousand, *e.g.* MILLI-AMPÈRE, one-thousandth of an ampère.

Millimetre. *See* WEIGHTS AND MEASURES.

Millimetre Pitches (*Eng.*) Screw threads whose pitch is a simple decimal fraction of the metre.

Milling (*Coins*). The grooves or indentations on the edge of a coin.

—— (*Eng.*) (1) Cutting metal, etc., by means of revolving circular cutters, having teeth of various shapes to suit the work in hand. The cutter is called a MILLING CUTTER, and is attached to a rotating spindle (which is either horizontal or vertical) driven by a machine termed a MILLING MACHINE, provided with a traversing table for holding the work. This table can move vertically as well as horizontally, and can also rotate about a vertical axis, so that any part of the work can be brought under the cutter as required. (2) The production of indentations or corrugations round the edge of a screw head, etc. *See* MILLED HEAD.

—— (*Woollen and Worsted Manufac.*) *See* FELTING.

Milling Machine (*Eng.*) *See* MILLING.

Milling Tool *or* **Wheel** (*Eng.*) A small steel wheel with corrugations on its edge which are the counterpart of those required to be produced on a milled head (*q.v.*) The steel wheel runs loosely on its axle, which is supported by a suitable handle, by which it is pressed against the blank as the latter revolves in the lathe.

Millon's Reagent (*Chem.*) Mercury is treated with its own weight of 63 per cent. nitric acid first in the cold and then with gentle warming till solution occurs: to the solution twice its volume of water is added, and it is allowed to stand till the precipitate subsides. The clear liquid is Millon's reagent. It gives a white precipitate with proteids, which turns brick red on boiling. Phenol and many of its derivatives give Millon's reaction.

Mill Race. The channel in which water is led to a mill wheel.

Mill Reams (*Paper Manufac.*) Reams of hand made paper consisting of 472 sheets.

Mill Rine, Mill Rind, *or* **Fer de Moline** (*Her.*) The iron which is fixed to the centre of a millstone. Used in conventional forms as a charge.

Mill Rolls (*Eng.*) The steel rollers used in the manufacture of bar iron.

Mimas (*Astron.*) The innermost satellite of Saturn.

Mimetese (*Min.*) An arseniate and chloride of lead, $3(Pb_3As_2O_8) . PbCl_2$. Hexagonal, occurring in yellow or brown crystals resembling Pyromorphite. Also called MIMETISITE and GREEN LEAD ORE. From Cornwall, the Caldbeck Falls in Cumberland, Saxony, Bohemia, etc.

Mimetisite (*Min.*) A synonym for MIMETESE (*q.v.*)

Mineral. The term mineral as used by commercial men signifies any native substance which is mined or quarried. In this sense freestone, fireclay, brick earth, oilshale, coal seams, and many other substances count as minerals. Amongst men of science the meaning attached to the word is much more restricted. They understand a MINERAL SPECIES to be an inorganic native compound whose chemical and physical properties vary so little in a large number of examples that these characters can be expressed in a short and definite description, by means of which any other specimens of that substance can be easily identified.

Mineral Acids (*Chem.*) A name used to denote the commoner inorganic acids. The *strong* mineral acids are hydrochloric, nitric, and sulphuric.

Mineral Chameleon (*Chem.*) A name given by Scheele to potassium manganate (*see* MANGANESE COMPOUNDS) because of the series of colours it gives on treatment with water—green, blue, violet, rose.

Mineral Dyes. *See* DYES AND DYEING.

Mineralogy. The systematic or scientific study of MINERALS (*q.v.*) It includes the determination of their chemical constitution, their physical characteristics, modes of formation, the measurement, description, and classification of their crystalline forms, investigation of their modes of occurrence and localities, and their economic values. The science thus possesses many points of contact with the sciences of Geology, Petrology, Metallurgy, and Mining, and may be considered to include the subsidiary science of Crystallography. *See also* SYSTEMS OF CRYSTALS.

Mineral Oils. The PARAFFIN class of hydrocarbons. *See* PARAFFINS.

Mineral Veins (*Geol.*) Fissures in the Earth's crust which have been filled with mineral substances of a nature different from that of the rock in which they are enclosed. These substances may be Quartz, Calcite, Dolomite, Barytes, Fluorspar, or, less frequently, any one or more of a few other substances. In nearly all cases mineral veins have been filled by the agency of water. *See* METALLIFEROUS VEINS.

Mineral Waters (*Chem.*) *See* WATER.

Mineral Wax (*Chem.*) Ozokerite (*q.v.*)

Miner's Dial (*Surveying*). An instrument used for determining the direction of lines. It consists essentially of a magnetic needle pivoted at the centre of a horizontal circle graduated into 360°, and provided with sights through which to observe stations on the line.

Minerva Machine. *See* TYPOGRAPHY.

Mine Tin (*Met.*) Tin ore extracted from a vein by mining instead of being obtained from alluvial deposits. *Cf.* STREAM TIN.

Miniature (*Paint.*) A portrait of very small dimensions generally executed in watercolours on ivory, vellum, or similar substance. The term was originally applied to the small watercolour drawings that adorned ancient manuscripts, and which were painted with *minium* or red lead.

Minim (*Music*). *See* NOTES.

Minimum Deviation (*Phys.*) The smallest angle through which a ray can be bent or deviated from its original path when acted on by a refracting system, such as a prism, etc. In the case of a prism, the minimum deviation occurs when the path of the refracted ray within the prism makes the same angle with the two sides of the prism.

Minimum, Minima (*Math.*) *See* MAXIMA AND MINIMA.

Minimum Thermometer (*Heat*). *See* MAXIMUM AND MINIMUM THERMOMETERS.

Mining. The term mining includes those processes by which the useful and precious minerals are explored, extracted, and dressed. It includes: (1) The search for the irregular veins or deposits of gold and other metals, and the comparatively regular seams of coal or ironstone; (2) the operations by which these minerals are "won"; (3) the arrangements adopted for their utmost utilisation. Two classes of minerals are worked—the metallic and the non-metallic. The most important examples of the former class are iron, gold, silver, copper, lead, tin, zinc, manganese, and arsenic; of the latter, coal, slate, gypsum, chalk, limestone, mica, salt, clays, and precious stones. The metallic minerals usually occur in rocks that have undergone more or less metamorphism or change, while the non-metallic are generally found in beds or stratified deposits. In searching for the former minerals, therefore, regions must be chosen where the greatest disturbances and upheavals have occurred, accompanied by great contortions of the rocks, eruptions of volcanic matter, and the formation of faults. Owing to the violent disturbances, the strata have been changed or metamorphosed and crystallised by heat. Metallic ore bodies are to be found here and in the fissures and other openings in the earth's crust. In most cases the vein-filling of metal bearing deposits has been accomplished by water, consequently porous rock formations are more likely to contain metallic ores than hard impervious strata. Very often ore deposits are to be found at the junction of two different rock formations. Bedded minerals, such as coal, stratified ironstone, fireclay, etc., occur in distinct layers. A BED or SEAM is a member of a series of stratified rocks. As the different non-metallic minerals are generally found in certain formations, and as they generally occupy one well defined position, the search for them is rendered comparatively simple. But all deposits are subject to irregularities. These may be due to their original mode of formation or to subsequent disturbances forming faults, heaves, throws, washouts, etc. (*q.v.*) In determining the position of veins, ore deposits, and seams it is generally necessary to make use of all the geological data available, to bore trial holes

through the various measures, or to drive tunnels or levels underground. The mode of occurrence of the various minerals greatly influences the method of winning them. Metals being found in veins, alluvial deposits, fragmental deposits or placers (*q.v.*) are worked in a different manner from seams of coal or masses of slate. The method adopted in any particular case must be the one most suited to that deposit, the object always being to extract as much mineral as possible from a given space at a minimum of cost. The various operations by which the minerals are extracted may be thus enumerated: (1) Opening the mine, (2) methods of working, (3) timbering, (4) tools and appliances, (5) haulage, (6) transmission of power, (7) machine mining, (8) winding, (9) draining, (10) ventilation and lighting. (1) OPENING THE MINE: A mine may be opened either by shafts or levels, and the location of the surface plant and mine opening will depend primarily on the nature and extent of the deposit, and secondarily on the facilities for obtaining water and for transporting the product to the market. If the shaft or tunnel is to be permanent it must be of a predetermined capacity. This will depend chiefly upon the output required; and this again will be determined by the thickness and extent of the deposit and the efficiency of the proposed hoisting and banking arrangements. Shafts are made circular, rectangular, or elliptical, according to the nature of the strata and the amount of timber or bricks available. They vary in size from 10 or 12 ft. to 20 or 24 ft. in diameter. Tunnels are driven where the mineral is near the outcrop, and these may be either in a level direction or inclined up or down, according to the inclination of the deposit or seam. They are generally rectangular in shape, though sometimes they are formed with straight sides and a semicircular arch above, lined with timber or brickwork. The mode of operation in sinking a shaft depends upon the character of the strata passed through and the quantity of water encountered. Ordinarily, sinking may be said to consist in boring holes for blasting, filling, sending up and banking the *débris*, and supporting or walling the sides. The holes are bored either by hand drills, hand machine drills, or power drills, the latter having been introduced during recent years for this work with good results. Explosives are then used for dislocating the rock, after which the *débris* is filled into hoppets and sent to the surface. If water is met with in large quantities it is necessary either to spend many hours per day in winding it (*i.e.* raising it by winding gear) or to erect adequate pumping machinery. Tunnels and drifts, though driven more or less horizontally, are excavated in a similar manner. In sinking or tunnelling through quicksand or other water bearing strata, special methods are adopted. (2) METHODS OF WORKING: These may be divided into OPEN WORK and CLOSED WORK. The former includes the working of all deposits having no overbearing strata or those in which the overlying material is removed by hand or machinery from the deposit. Thus all quarries and fragmental deposits or placers are open work. There are many advantages of such a system of working: underground roadways have not to be kept open and in good repair; there is less danger from accidents due to falls of ground, blasting, or accumulations of gas; the men work under healthier conditions and are enabled to select and extract the ore more easily. Open work may be divided into two general classes: (*a*) Where the greater portion of the deposit is valuable and has to be removed, (*b*) where the valuable portion is only a small part of the whole deposit. In the first case, as in quarrying and in ordinary mines, the material is removed by hoists, cableways, or tunnels; or, again, the deposit may be stripped and tunnels driven through the material from valleys or adjacent shafts: this is known as the MILLING SYSTEM. Placers may be worked by means of a stream of water from a nozzle directed against the deposit. When the material has been loosened it is directed so as to flow through sluices to the dressing tables. This is known as HYDRAULIC MINING. Placer deposits may also be worked by mechanical means. If a metal-bearing deposit lies below water level, the material is raised by means of a dredge. CLOSED WORK includes numerous methods of both coal and metal mining. In the case of regular bedded deposits, such as coal, fireclay, and ironstone, elaborate systems can be adopted which are impossible in irregular deposits interrupted by faults, etc. In the case of a vein the shaft is sunk on the course of the lode, and so as to intersect it at a depth of 500 or 600 ft. From the shaft, at intervals of 30, 40, or 50 yards, crosscuts are driven to the lode, and from the point of intersection levels are driven parallel with it. The material is then got out by means of UNDERHAND or OVERHAND STOPING: underhand stopes are workings arranged like steps, the miner filling the ore from the floor into boxes, working gradually down in a series of terraces. In overhand stoping the ore is broken down from above as the working progresses. Wider lodes and certain beds are worked by modifications of these systems. In working coal seams, main roads or levels are driven in different directions, and after leaving a solid pillar of coal to protect the shaft of 50 to 150 yards in diameter, the workings are opened either on the PILLAR AND STALL or the LONGWALL system. In the former method the estate to be gotten is divided or cut into a series of separate blocks, panels, or pillars by pairs of narrow tramroads, after which the pillars are got out one by one, generally starting from the boundaries of the estate; this system is called STRAITWORK. By longwall is meant the method of taking out the whole of the coal in one long wall or face without first driving narrow roads, the access to and from the face being by means of roads constructed through the waste or goaf, and formed of the dirt or shale obtained in excavating the mineral; this is known as WIDEWORK. In thin, thick, or highly inclined seams modifications of one or the other of these systems are adopted. (3) TIMBERING: The supporting of the roadways and workings of a mine is a very important consideration. The chief timbers used are those called soft woods, such as fir, pine, and larch, whose chief characteristics are straightness, regularity, and lightness. For bars and other supports requiring special strength a few hard woods are used, such as oak and beech. Many arrangements of props, bars, sprags, chocks, etc., as the various mining timbers are called, are adopted according to the nature of the roof, floor, and sides, and the height of the excavations. In metalliferous mining it is usual to joint sets of timber together so as to completely support all sides; in coal mining the roof only may need support, although it is invariably the custom to timber the sides of roadways as well as the roof. For some purposes brickwork, masonry, and concrete are employed, while iron and steel props and bars are now coming into use. (4) TOOLS AND APPLIANCES: As the strata in which the miner works is generally of a

very hard nature, it is necessary that all his tools should be of good quality, and especially those tools which daily become worn and need continual sharpening. The most common tools are picks, shovels, hammers, wedges, and drills. The appliances include apparatus for charging and firing shot holes, and instruments for setting and drawing props. (5) HAULAGE: The haulage of the mineral from the workings to the shaft is done to a great extent by either men and horses or by machinery and ropes and chains. The roads along which the tubs or corves are drawn are called ENGINE PLANES or HAULAGE ROADS. Ropes or chains cannot be employed along all underground ways, consequently it is necessary for the miner to haul the coal along the faces and drawing roads. The tubs run on bridge or flange rails laid on wooden sleepers, points and shunts being fixed where necessary, and pulleys arranged overhead, in the case of engine planes, to direct the rope. (6) TRANSMISSION OF POWER: For the purposes of hauling, coal cutting, and pumping it is necessary to transmit power from the surface to the workings. Engines or motors driven by steam, compressed air, or electricity are used. As steam is often a serious danger underground, the two latter sources of power are substituted. The former is the safest means, and is a common motive power in the chief metalliferous fields and in many coal mines. During recent years the extension of electric power to mining work has been remarkable, and it is now used in many cases for every class of work both above and below ground. (7) MACHINE MINING: Machines have superseded hand labour in many departments. Power machine drills are used for drilling holes in shafts, tunnels, and at the working face; HEADING and SHEARING machines are used to cut the sides of roadways, and various forms of mechanical cutters are in use for undercutting coal. (8) WINDING: The hoisting of the mineral from the workings to the surface is carried on in both inclined and vertical shafts by means of several appliances, the essential parts being a WINDING ENGINE, which actuates a drum carrying a rope, the latter being alternately coiled and uncoiled from the drum. If the shaft is a deep one other appliances are installed, by means of which the load may be balanced at all parts of its journey, thus reducing the strain on the winding engine. Guides of wood or iron, or wire ropes, are used to keep the cages steady in their transit, and safety keps or catches are fixed at top and bottom to prevent the cages accidentally falling down the shaft. (9) DRAINING: Directly the miner gets below the surface of the ground he is liable to be impeded by water, which may constantly increase in amount as the sinking or workings get deeper. If the quantity of water is not large, it may be got out by winding or by means of water levels and drainage tunnels. These latter are very useful in hilly districts. When pumps are used, two general systems are employed: (*a*) the pump may be placed underground and operated by an engine on the surface, power being transmitted by rods; or (*b*) both engine and pump may be placed underground, the former being driven by steam, compressed air, hydraulic, or electric motor. The types usually employed are Cornish pumps, lift or force pumps, pulsometers, centrifugal pumps. (10) VENTILATION AND LIGHTING: The successful ventilation of a mine may be briefly described as keeping the atmosphere of the mine in as healthy and pure a condition as possible without useless expenditure. To accomplish this is one of the most important duties of the mining engineer. As the natural ventilation of the mine is rarely sufficient, a current may be produced either by a furnace or fan. Both arrangements depend for their success on the establishment of a difference in pressure of the air in the intake and return currents. In the former case this is achieved by heat, just as a draught is caused in a room by a fire; in the latter case a depression is obtained by means of the fan's action, the air flowing in all cases from the point of greater pressure to the point of depression. Underground the air is conducted by means of air doors, screens, air pipes, crossings, stoppings, etc., to the utmost limits of the mine, thus supplying fresh air to the workman and carrying off the noxious gases produced by the firing of shots, the breathing of men and horses, or escaping from the strata. Mines are lighted by safety lamps, candles, torches, or electricity. In fiery mines, safety lamps only can be used. In safe mines, and during the sinking of shafts or tunnels, candles are most common. Electricity is used in the neighbourhood of the shaft bottom, but so far has been found unsuitable for use in the workings. After the ore leaves the mine it must be DRESSED before it is ready for use. For this purpose every mine has its own more or less extensive and elaborate arrangements for dealing with the raw material. It is put through various processes, including crushing, stamping, screening, sizing, classifying, washing, and concentrating, after which it is loaded into wagons or barges and sent to the market. ORE DRESSING AND PREPARATION OF COAL: The object of crushing ore or coal is to free the valuable constituents from the gangue or other worthless constituents, so that they may be afterwards separated, or crushing may be done in order to reduce the size of the individual pieces. The various types of machines for crushing are jaw crushers, gyratory crushers, cracking or disintegrating rolls, roller mills, stamps, and hammers, all of which are designed to reduce the raw material to a convenient size for the subsequent processes. After crushing, the material passes to the screening and sizing machines, where the various sizes are separated from each other. CLASSIFIERS and CONCENTRATORS are machines for thoroughly separating the ore from the gangue or for taking out the dirt from the coal. In both cases the principle employed in doing this is the same, *viz.* making use of the varying specific gravities of different minerals. The material is washed by water into special JIGS or troughs, and while the water is in motion the heavier particles fall to the bottom, the lighter ones arranging themselves in layers according to their density. It is owing to the introduction of greatly improved dressing machines that many deposits of ore and seams of coal are now being worked which formerly were considered of little value, because of the small proportion of valuable products contained in them in the one case, or the large quantities of dirt and inferior coal intermixed in the other.—J. T.

Minion (*Typog.*) Type between brevier and emerald in size. *See* TYPE.

Minium (*Chem.*) A common name for red lead. *See* LEAD COMPOUNDS.

—— (*Min.*) A compound of lead and oxygen now regarded as a lead plumbate, $2PbO \cdot PbO_2$; of the same composition as RED LEAD (*q.v.*) It is a rare mineral, occurring as a pulverulent decomposition product of other lead ores. It has been sparingly found at many localities where Galena or Cerussite occurs.

Minivor. A white fur obtained from the Siberian squirrel, used on peers' robes.

Minnikin (*Typog.*) The smallest size of type made.

Minor (*Music*). Lesser. *See* MAJOR.

Minor Axis. The shorter diameter of certain figures, *e.g.* of the Ellipse.

Minore (*Music*). Minor; used sometimes when a piece goes from the major key to that of the tonic minor. *Cf.* MAGGIORE.

Minor Planets (*Astron.*) A multitude of small planets which revolve round the sun between the planets Mars and Jupiter.

Minor Tone (*Sound.*) The ratio of the two notes of frequencies 10 and 9, *i.e.* the interval $\frac{10}{9}$.

Minotto Cell (*Elect.*) A modification of the DANIELL CELL (*see* CELLS, PRIMARY), having a flat copper plate lying at the bottom of a jar, covered by a mass of sawdust. The zinc plate rests on the latter, and the porous pot is dispensed with.

Minster. Originally the name for a monastery; subsequently the name signified the church attached to a monastery, and more recently a cathedral church, *e.g.* York Minster.

Minute. *See* WEIGHTS AND MEASURES.

—— (*Architect.*) *See* MODULE.

Mirabilite (*Min.*) Native Glauber Salt, hydrous sodium sulphate, $Na_2SO_4 . 10H_2O$. Soda = 19·3, sulphuric acid = 24·8, water = 55·9 per cent. Monosymmetric; also as a white efflorescence. It loses its water on exposure to air and becomes opaque. From Kirkby Thore in Westmorland, Hallstadt in Austria, Bohemia, etc.

Mirage (*Meteorol.*) An appearance suggesting water, seen in hot countries, and due to total internal reflection from a layer of hot and rarefied air lying next to the heated ground.

Mirbane, Essence of (*Chem.*) A common name for nitrobenzene (*q.v.*) It is used as a cheap flavouring agent in confectionery, etc.; it has a sweet almond-like smell: it is poisonous.

Mirror (*Phys.*) An object having a polished surface of regular form; the principal forms are plane, concave, and convex. The latter are commonly portions of spheres; but for certain purposes mirrors are made PARABOLIC in form. *e.g.* when required for use in reflecting telescopes.

Mirror Galvanometer (*Elect.*) *See* GALVANOMETERS.

Miserecorde (*Arms*). A slender dagger, generally three sided, intended to enter the joints of armour to give the *coup de grace* to a fallen antagonist. Worn by knights and others on the right hip.

Miserere (*Architect.*) A hinged bracket on the underside of a stall seat in a church, on which, when the seat was turned back, an ecclesiastic could rest without actually sitting down.

Mispickel (*Min.*) Sulpharsenide of iron, FeAsS. Iron = 34·3, arsenic = 46·0, sulphur = 19·7 per cent. Orthorhombic; also, and more often, massive. Tin-white to steel grey; sometimes contains cobalt or nickel. In association with other metalliferous ores in Cornwall, Devonshire, Cumberland, Saxony, Bohemia, the United States, etc.

Missal. The name applied to a manuscript or printed book containing the office or prayers of the Mass used in the Roman Catholic Church. They are often designed after the style of mediæval manuscripts.

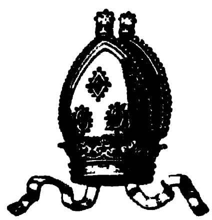
Mist (*Meteorol.*) *See* FOG.

Mistral (*Meteorol.*) The cold N.W. winds of Mediterranean France, generally occurring in the winter.

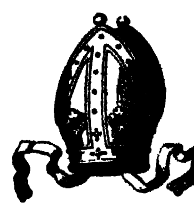
Miter (*Carp., etc.*) An alternative spelling of MITRE (*q.v.*)

Mitis Castings (*Eng.*) Castings made by fusing wrought iron with a trace of aluminium, and pouring into a mould of special construction. Objects produced this way have practically all the properties of forgings, and the process will probably become increasingly common.

Mitre (*Cost.*) A ceremonial headdress, pointed and cleft at the top, worn by prelates and sometimes by abbots. Originally the mitre was a plain head band or bonnet, with two lappets at the side. It



MITRE OF BISHOP OF DURHAM.



MITRE OF BISHOP.

assumed the present form in the fifteenth century. The mitre of the Bishop of Durham rises from a ducal coronet; the mitre of a Bishop rises from a circlet.

—— (*Her.*) An ecclesiastical cap denoting rank and dignity. It is sometimes used as a charge, but where it appears as a badge of office it replaces the crest ordinarily found above the arms, and the helmet is discarded. On the arms of Berkeley, fourteenth century, this crest is seen with helmet and mantling.

Mitre Arch (*Build.*) An arch consisting of two stones in the form of a gable. It is not, strictly speaking, an arch.

Mitre Board *or* **Shoot** (*Carp., etc.*) A board provided with a guide or fence set at a suitable angle for planing the end of a piece of wood which is to form part of a mitre joint. The mitre board is used when the joint has not been cut with sufficient accuracy by the use of the saw and mitre box (*q.v.*)

Mitre Box (*Carp., etc.*) A device for guiding a tenon saw in order to cut off the end of a piece of wood at an angle (usually 45°) in making a mitre joint.

Mitre Clamp (*Carp., etc.*) A device for holding the members of a mitre joint in position while being glued up or otherwise fastened.

Mitred Clamp (*Carp. and Join.*) A piece of wood forming a border at right angles to the grain of a board and mitred at the ends.

Mitre Joint. A joint between two pieces of material which meet at an angle, the two pieces being so cut that there is a plane surface of contact bisecting the angle. In the commonest cases the joint is right angled, and the surface of contact is formed by cutting off the end of each piece at an angle of 45°.

Mitre Shoot (*Carp., etc.*) *See* MITRE BOARD.

Mitre Square (*Carp., etc.*) A steel blade set in a stock at an angle of 45° for testing the accuracy of mitre joints.

Mitre Wheel (*Eng.*) A bevel wheel whose teeth are at an angle of 45° with the axis.

Mitring (*Bind.*) Finishing or ornamenting the cover of a book with straight lines which meet each other without overrunning.

Mixing (*Cotton Manufac.*) A system of combining cotton fibres possessing similar characteristics with the object of (*a*) reducing the cost of spun thread, (*b*) altering the shade or colour of thread, (*c*) improving the spinning and quality of a lower grade of cotton.

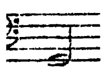
Mixing Chamber (*Eng.*) The space in gas and petrol engines in which the explosive gas is mixed with air; sometimes this occurs in the cylinder itself.

Mixing Jet *or* **Mixed Gas Jet.** *See* OXYHYDROGEN FLAME.

Mixolydian (*Music*). *See* MODES.

Mixture (*Chem.*) Two, or more, substances, associated together, but not combined. *Cf.* COMPOUND.

Mixture (*Music.*) An organ stop which controls several ranks of comparatively small pipes to each key. The most frequently found mixture is that of three ranks, consisting generally (though other combinations will sometimes be found) of the 17th, 19th, and 22nd of the 8 ft. tone. With this combination the result, when



is played with the mixture stop only drawn, will be

As the scale ascends, the higher ranks are discontinued gradually, and ranks of lower tone substituted. This is called a "break." Any number of ranks from three to five may be found in the mixture. This stop is found under several names, *e.g.* Sesquialtera, Cornet, Furniture, etc., and adds great brightness to the full organ.

—— (*Textile Manufac.*) *See* BLENDING.

—— (*Typog.*) When three or more types are used in the composition of a work, it is known by the above term, and involves extra charges.

mm. A common contraction for MILLIMETRE. *See* WEIGHTS AND MEASURES.

M.M.F. (*Elect.*) A contraction for MAGNETO-MOTIVE FORCE (*q.v.*)

Mocha Stone (*Min.*) A synonym for MOSS AGATE (*q.v.*)

Mock *or* **Wild Lead** (*Mining*). A Cornish term for BLENDE (*q.v.*)

Mock Moons *or* **Paraselenæ** (*Meteorol.*) *See* HALOS.

Mock Suns *or* **Parhelia** (*Meteorol.*) *See* HALOS.

Model (*Art*). (1) A standard pattern or object which is to be reproduced. (2) A copy in miniature of an object. (3) A pattern on a small scale of something to be reproduced on a larger scale. (4) A person from whom an artist studies proportions, details, etc., *i.e.* one who sits or poses to an artist.

Modeller (*Pot.*) An artist or craftsman who forms in clay or wax the original model from which Plaster of Paris moulds are subsequently made.

Modelling (*Sculp.*) Constructing with some plastic material, *e.g.* clay or wax, a model which is to be reproduced in a more durable substance, such as marble, wood, etc.

Moderato (*Music*). (1) At a moderate pace. (2) Moderately, *e.g.* *Allegro moderato*, moderately cheerful.

Modern Face (*Typog.*) A book fount of modern character and style. It differs from Old Face or Antique in several respects, *e.g.* in the type being (*a*) not so round, (*b*) the serif being more accentuated, (*c*) the figures ranging both at the top and bottom.

Modes (*Music.*) (1) The ecclesiastical modes consist of fourteen scales, arranged in two classes, Authentic and Plagal. Of these fourteen, two, xi. and xii., are theoretical only, and not practical, xi. (the Authentic) not having a perfect fifth between the first and fifth notes and a perfect fourth between the fifth and eighth notes, and xii. (the Plagal) not having a perfect fourth between the first and fourth notes and a perfect fifth between the fourth and eighth notes, which will be found to be the case in the other twelve modes according as they are Authentic or Plagal. Each Plagal mode is derived from the Authentic, and bears the same name with the prefix Hypo-; it also has the same Final. The Final is the last note of the melody or Canto Fermo. Dr. C. W. Pearce, in his *Composers' Counterpoint* gives the following rule for discovering the mode in which an old melody is written: "If there is no key signature, we may assume that the melody is untransposed, and that the last note is the Final. Next, let us examine the range of the melody, and discover if the Final is approximately the lowest note used; should this be so, the Mode will be Authentic, and its number can be easily ascertained from the Final. But if, on the other hand, the Final occupies an approximately central position in the melodic range, the Mode will be Plagal. If the melody has a key signature, this is a sign that it has undergone transposition; in this case it will be necessary to restore the original pitch by bringing the melody into a range which requires no key signature; then the Final and its position in the range will determine the Mode as before."

TABLE OF THE MODES.

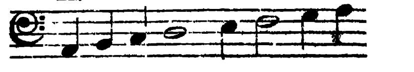
The Final is shown by a semibreve, and the Dominant by a minim. The semitones, of course, always fall between E and F, and between B and C.

AUTHENTIC.

I. DORIAN.

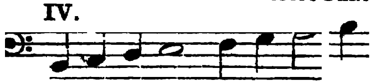
PLAGAL.

II. HYPO-DORIAN.



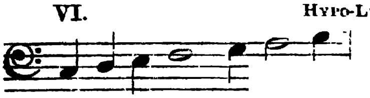
III. PHRYGIAN.

IV. HYPO-PHRYGIAN.



V. LYDIAN.

VI. HYPO-LYDIAN.

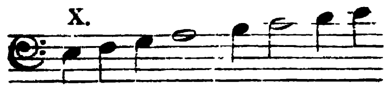


VII. MIXO-LYDIAN.

VIII. HYPO-MIXO-LYDIAN.

IX. ÆOLIAN

X. HYPO-ÆOLIAN



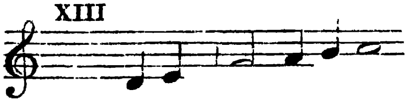
XI. (NOT IN USE.) LOCHRIAN.

[THEORETICAL FINAL B, DOMINANT G.]

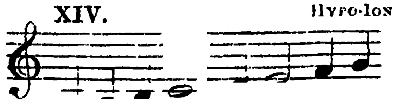
XII. (NOT IN USE.) HYPO-LOCHRIAN.

[THEORETICAL FINAL B, DOMINANT E.]

XIII IONIAN.



XIV. HYPO-IONIAN.

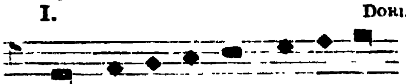


The late Rev. Thomas Helmore, in his "Primer of Plain Song," calls the 11th and 12th Modes respectively the Mixo-Lochrian and Hypo-Mixo-Lochrian. He also gives the following table of the Mode Finals and Dominants :

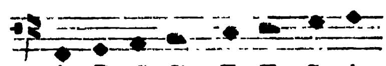
No. of Mode ..	1	2	3	4	5	6	7	8	9	10	13	14
Final	D	D	E	E	F	F	G	G	A	A	C	
Dominant	a	f	c	a	c	a	d	c	e	c	g	

The odd numbers are the Authentic, as pointed out above, and in each of these it will be seen that the Dominant is the fifth note of the mode, and in the even numbers (Plagal) the Dominant is a third below the corresponding Authentic, with this exception : B is never used for a Dominant, C being substituted on every occasion whether Authentic or Plagal. Modes xiii. and xiv. are often spoken of as xi. and xii., owing to the theoretical modes never being used. Tradition says that St. Ambrose authorised the first four Authentic modes, and that later St. Gregory the Great added the corresponding four Plagal in the sixth century, the remaining modes being added later about the end of the eighth or beginning of the ninth century under the auspices of the Emperor Charlemagne. The limited compass of these modes enables the music to be written on four line staves with the (C) and (F) clefs moved to different lines according to the range of the mode, *e.g.*

I. DORIAN.



II. HYPO-DORIAN.



It will be seen that the modern major scale of C is identical with the Ionian Mode (xiii.) (2) The manner of arranging the notes of a scale is called a Mode ; hence we have the Major Mode and the Minor Mode, according to the arranging of the semitone in the lower tetrachord of the scale (*q.v.*)

Modillion (*Architect.*) A projecting bracket in the form of a scroll used at intervals under the corona of the Roman Corinthian cornice. The space between the two modillions is usually equal to about twice the width of the modillions. *See* ANCONES; CONSOLE; ARCHITECTURE, ORDERS OF; CARTOUCH.

MODILLION.

Modulation (*Music*). The act of passing from one key to another. Some writers call a temporary modulation a "transition."

Modulator (*Music*). A chart used in teaching music by the Tonic Sol-fa System (*q.v.*)

Module. A unit of measurement used in classical architecture. It is equal to half the diameter of the shaft immediately above the congé at the base, or, in the case of the Greek Doric Order, half the diameter of the shaft where it rests on the stylobate. The thirty divisions into which the module is divided are known as PARTS or MINUTES. Different values have, however, been given to the module, and it has not always been divided into thirty parts. The lower diameter of the shaft is sometimes taken as a unit; and in this case the module is divided into sixty minutes.

Modulus (*Phys., Eng.*) A coefficient expressing some physical constant of a given material; *e.g.* the Modulus of Elasticity is the Coefficient of Elasticity. *See* ELASTICITY.

Modulus of Elasticity. *See* ELASTICITY.

Modulus of Resilience (*Eng.*) *See* RESILIENCE.

Mohair. A textile material made of the hair of the Angora goat.

Mohair Lustre (*Textile Manufac.*) Dress fabrics. plain woven, consisting of cotton warp and mohair weft.

Moiré Antique (*Silk Manufac.*) A watered effect given to the surface of plain, ribbed, or corded silk fabric by carefully folding the material up the centre and then subjecting it to great pressure between heated cylinders.

Molasses. *See* CANE SUGAR.

Molecular Conductivity (*Chem.*) *See* SOLUTIONS.

—— (*Elect.*) A constant by which the number of gram molecules (*q.v.*) of an electrolyte in a litre of solution must be multiplied in order to give the specific conductivity (*q.v.*) of the solution. Let c be the number of gram molecules, K the specific conductivity, m the molecular conductivity; then $K = mc$.

Molecular Covolume (*Chem.*) *See* MOLECULAR SOLUTION VOLUME.

Molecular Formula (*Chem.*) A formula which merely stands for one molecule of any substance. Thus H_2O is the molecular formula for water.

Molecular Magnet (*Elect.*) A uniformly magnetised body may be conceived as being capable of being broken up into a great number of small magnets, each having the same intensity of magnetisation. If the process of subdivision be carried to its ultimate extent, we obtain a series of magnetised molecules. Theory assumes that these molecules possess permanent magnetism. When a bar of iron is unmagnetised, the molecules lie with their magnetic axes in all directions; but when magnetised, a certain number of the molecules turn in such a manner that their magnetic axes are parallel, and their north poles point in one direction. If only a small number of the molecules are arranged in this manner, the bar is feebly magnetised; but if a great number, then the bar is strongly magnetised. When the number reaches a maximum, the bar is magnetised as strongly as possible, or is SATURATED. *See* SATURATION. If the magnetising force be withdrawn, some of the molecules do not retain their regular arrangement, and the bar loses some of its magnetism. In the case of very soft iron nearly the whole may be lost, while in the case of very hard steel nearly the whole magnetism may be retained. It is to be noticed that this theory is independent of any explanation of the cause of the magnetic properties of the individual molecules.

Molecular Magnetic Rotation. All liquids when placed between the poles of a powerful electro magnet have the power of rotating a ray of polarised light. The rotations of the substance and of water are observed in equal tubes, and the densities of the substance and of water are accurately determined. The molecular magnetic rotation is then given by the formula

$$\frac{r \times M}{d} \div \frac{r' \times M'}{d'}$$

where r and r' are the observed rotations of the substance and water respectively, M and M′ their molecular weights, and d and d' their densities. The constants so determined appear to be of great value; but irregular results are observed with the initial members of homologous series, probably owing to molecular association. The method of applying the constants is best illustrated by examples: (1) The members of a homologous series differ in their M.M.R. by 1·023 for each CH_2. The M.M.R. of pentane being 5·638, that of hexane should be 6·661; observed value, 6·670. (2) To obtain the value for an acid of the fatty series, the M.M.R. of one acid is found, then the method is as follows:

M.M.R. of oenanthylic acid, $C_7H_{14}O_2$	= 7·552
$7 \times 1{\cdot}023$	= 7·161
	0·391

0·391 is called the series constant for the fatty acids. General formula for M.M.R. of fatty acids is:

$$C_nH_{2n}O_2 = 0{\cdot}391 + 1{\cdot}023_n.$$

(3) In a similar way values are deduced for:

(*a*)	The difference of H_2 between a saturated and an unsaturated compound	= 1·112.
E.g.	Ethyl crotonate, 7·589 / Ethyl butyrate, 6·477	Diff. = 1·112
(*b*)	Oxygen in alcoholic hydroxyl	= 0·194
(*c*)	„ „ acid hydroxyl	= 0·137
(*d*)	„ „ carbonyl (CO) group	= 0·261

(4) The method of applying M.M.R. to constitutional questions is illustrated by the following example:

Observed M.M.R. of ethyl crotonate $CH_3 . CH : CH . COOC_2H_5$	7·589
M.M.R. of oxygen in alcoholic hydroxyl (3.*b*)	0·194
Calculated M.M.R. of ethyl hydroxycrotonate $CH_3 . COH : CH . COOC_2H_5$	7·783

Again:

Observed M.M.R. of ethyl hydroxybutyrate $CH_3CHOHCH_2COOC_2H_5$

Difference of H_2 for unsaturation (3.*a*)

Now the series constant of a compound which belongs to two different classes can be found by taking the mean of the series constants for each class. This statement is confirmed by experience. So we have:

Series constant for ester of acetic acid	0·370
Series constant for a ketone	0·375
	2)0·745
	0·373
$6 \times 1{\cdot}023$	= 6·138

Calculated M.M.R. of ethyl acetoacetate
$CH_3CO . CH_2COOC_2H_5 = 6{\cdot}511$
Observed M.M.R. of ethyl acetoacetate
$CH_3CO . CH_2COOC_2H_5 = 6{\cdot}501$
$\overline{{\cdot}010}$

Thus ethyl acetoacetate has the formula $CH_3CO . CH_2 COOC_2H_5$, and not $CH_3C . OH : CHCOOC_2H_5$, which is ethyl hydroxycrotonate. Similarly ethyl ethylacetoacetate has been shown to have the ketone form. All the work on this subject has been done by W. H. Perkin, sen.

Molecular Refractive Power (*Chem.*) The molecular refractive power of a substance is $\frac{n^2-1}{n^2+2}\cdot\frac{M}{d}$, when n is the refractive index of the substance, M its molecular weight, and d its density. Sodium light is used. Brühl, who has done an enormous amount of work on this subject, assigns values for the M.R.P. to the various atoms and groups in a similar way to Perkin for molecular magnetic rotation. His results are often of use in settling questions of constitution. The following example will show the application of the method:

M.R.P.

	Observed.	Calculated for Keto Form.	Calculated for Enol Form.
Methyl acetoacetate	27·20	27·17	28·11
Ethyl acetoacetate	31·99	31·78	32·72

Thus ethyl acetoacetate has the formula $CH_3COCH_2 COOC_2H_5$, and not $CH_3 . C . OH : CH . COOC_2H_4$.

Molecular Rotatory Power (*Chem.*) The rotation ($a°$) of the plane of polarisation of light by a substance of density d, in a tube l decimeters long is observed. The kind of light used is generally the sodium light—the D line in the sodium spectrum. Then the specific rotatory power, denoted by $[a]_D$ is $\frac{a}{l.d.}$. When the substance is a solid it is dissolved in an inactive solvent: in this case the specific rotatory power is $[a]_D = \frac{100a}{p.l.d.}$, where d is the density of the solution, and p is the weight of the substance in 100 grams of the solution. The temperature must be stated, for the value varies with the temperature. The molecular rotatory power is the specific rotatory power multiplied by the molecular weight and divided by 100.

Molecular Solution Volume (*Chem.*) Graube (I) defines this as follows:

$$V_m = \frac{m+l}{d} - \frac{l}{s}$$

when Vm is the molecular solution volume, m the molecular weight of the dissolved substance, l the quantity of the solvent which contains one gram molecule of the substance, d the density of the solution, and s the density of the solvent *in the solution*—the change in volume which occurs on solution being attributed to the solvent. The constants so deduced are supposed to represent the spaces occupied by the molecules of compounds and the atoms of elements more exactly than the constants deduced from the quotients

$$\frac{\text{Molecular Weight}}{\text{Specific Gravity}} \text{ and } \frac{\text{Atomic Weight}}{\text{Specific Gravity}}$$

On these Traube founds a new system of arranging the elements—those of equal solution volumes occurring in the same class. He also shows that molecular solution volumes are of use in deciding when ring formation has occurred. Thus the calculated value of Vm for glycocoll (*q.v.*), on the assumption that it is *not* a ring compound, is 55·7; the observed value is 42·9. As ring formation is assumed to cause diminution of Vm, Traube believes glycocoll to be a ring compound when in solution. When the value for the observed molecular solution volume of a compound is compared with that calculated from the atomic solution volumes of its elements, the former is seen to be larger than the latter, the difference between the two for a series of alcohols at 15° in aqueous solution was found to be fairly constant, and in the mean = 12·4. This constant is called the molecular covolume; it is supposed to represent the space which the molecules have at their disposal for motion of translation. This new constant is found to exist for homogeneous liquids and solids, only for these it has a different value than 12·4, and a method of determining molecular weights is founded on it; but as the values so deduced are not always the correct values, the method is not given here. For further information Traube's work *Raum der Atome* must be consulted.

Molecular Volume (*Chem.*) The quotient $\frac{\text{Molecular Weight}}{\text{Specific Gravity}}$ is called the molecular volume. It should represent the relative volume occupied by a molecule of any given compound; and some regularity exists between the molecular volumes of related substances, but not sufficient regularity to enable any safe conclusions to be drawn as to constitution. For instance, isomeric compounds should have the same molecular volume, and in many cases they have nearly the same molecular volume; but exceptions are of such frequent occurrence as to render a generalisation impossible. The failure of this constant to be of service in constitutional problems is due to the fact that it is not yet known under what conditions the specific gravities of liquid and solid substances are comparable.

Molecular Weight (*Chem.*) As the absolute weight of a molecule of any substance is not known with accuracy, molecular weights are expressed in terms of an arbitrary unit. We shall take as unit the weight of one atom of hydrogen. The definition of molecular weight, therefore, will be: the weight of one molecule of the substance in question, element or compound, when the hydrogen atom is taken as unit of weight. To determine a molecular weight we make use of two further principles: first, Avogadro's Law (*q.v.*); second, the atomicity of the molecule of some standard substance. We shall take hydrogen as the standard substance, and assume that its molecule contains two atoms. We now put

$$\frac{\text{Weight of one litre of any gas}}{\text{Weight of one litre of hydrogen at same temperature and pressure}} = \text{Vapour density of substance.}$$

Let the weight of the molecule of the gas be M, and let there be n molecules of any gas in a litre at the same temperature and pressure; then

$$\frac{M . n}{2n} = \text{Vapour density.}$$

That is, we have always the molecular weight of any gas is twice the vapour density. Molecular weights of gases or substances which can be vapourised are always determined by an application of this rule. For determination of molecular weight by lowering of the freezing point and raising of the boiling point, *see* SOLUTIONS. In chemical measurements quantities are always expressed in terms of molecular

weights. *See* MASS ACTION, SPEED OF REACTIONS, SOLUTIONS.

Molecule (*Chem.*) Imagine a piece of cane sugar submitted to a process of mechanical subdivision carried so far that at last a particle of sugar is obtained which on further division loses the properties of cane sugar; that is, the particle of sugar gives two or more particles which are evidently not sugar. Then this ultimate particle is called a molecule. As we may extend this imaginary process to any compound, it is clear that we can define the molecule of a compound as the smallest particle of a compound that can exist. In the case of an element the molecule is not always the smallest particle that can exist; the atom is the smallest particle of an element that can exist. So we must define the molecule of an element as the smallest particle of an element that can exist in the free state; that is, uncombined with other atoms of the same or different elements. The atom and the molecule appear to be identical in most metals and in the inert gaseous elements (helium, argon, etc.) and in the vapour of certain non-metals at a very high temperature, *e.g.* iodine at 1,500°; these elements are therefore said to have monatomic molecules. Conversely, it may be said that if a substance is proved to have a monatomic molecule, it must be regarded as an element. Neither the absolute size nor absolute weight of a molecule is known with much accuracy; the order of magnitude to which they belong may be gathered from the statement that in one litre of any gas at the ordinary temperature and pressure there are something like eighteen thousand millions of millions of millions of molecules.

Moline (*Her.*) *See under* CROSS.

Moll (*Music*). The German term for Minor, *e.g.* H moll = B minor, the term for major being *Dur*, *e.g.* B. *dur* = B♭ major.

Molto (*Music*). Much: very.

Molybdenite (*Min.*) Sulphide of molybdenum, MoS_2. Molybdenum = 59·1; sulphur = 40·9. Hexagonal. When fresh it is the colour of newly cut lead. It gives a grey streak on paper. Thin lamellæ are flexible, but not elastic. It is soluble in nitric acid. It occurs sparingly in metamorphic rocks in Cornwall, the Caldbeck Fells in Cumberland, Norway, Bohemia, etc.

Molybdenum (*Min.*) This element does not occur native. Its principal native compounds are MOLYBDENITE *and* MOLYBDINE (*q.v.*)

Molybdenum and its Compounds (*Chem.*) Molybdenum, Mo. Atomic weight, 96. Is a white metal which does not change in air at the ordinary temperature, but at 600° it is oxidised to the trioxide, which sublimes; in oxygen at the same temperature it burns; heated in steam at 700°, it gives a mixture of the di- and trioxides; dilute acids do not attack it; nitric acid and hot concentrated sulphuric acid oxidise it. At a high temperature it combines with carbon to form a carbide, Mo_2C. It occurs naturally chiefly as molybdenite, MoS_2, which resembles plumbago. The metal is obtained by reducing any of its oxides or chlorides by heating them in a stream of hydrogen; also by heating the dioxide with sugar charcoal in a carbon crucible in the electric arc (800 ampères and 60 volts) for six minutes; that is, so that the charge near the sides of the crucible is not melted, for the melted metal readily dissolves carbon. This metal belongs to the same group as chromium. It forms an enormous number of compounds. Many oxides are known. The dioxide is obtained pure by fusing ammonium molybdate with potassium carbonate and boron oxide, and extracting with water, when it remains as a brown solid, violet by reflected light. The *trioxide* is a white solid which turns yellow on heating, then melts and sublimes; sparingly soluble in water; with alkalis it yields the molybdates; with strong acids it yields the *molybdenyl salts*, *e.g.* $MoO_2 . SO_4$. It is obtained by heating the native sulphide, contained in a hard glass tube, in a current of air, to such a temperature that the trioxide formed sublimes. Molybdic acid, $H_2MoO_4 . H_2O$, is a yellow solid formed when nitric acid is added to a solution of ammonium molybdate and the mixture allowed to stand. A large number of simple and complex molybdates is known. Ordinary "ammonium molybdate" is probably a double salt derived from trimolybdic acid, $H_6Mo_3O_{12}$, and having the formula $(NH_4)_3H_3Mo_3O_{12}(NH_4)_2H_4Mo_3O_{12}$. It is resolved into its constituents on solution in water. It is a white crystalline solid, obtained by evaporating a solution of the trioxide in ammonia. It is a valuable test for phosphates and arsenates. When an excess of a solution of "ammonium molybdate" acidified with nitric acid is added to a solution of a phosphate, a yellow precipitate of hydrated ammonium phosphomolybdate is formed,

$$(NH_4)_5H . (PO_4)_2 23MoO_3 8H_2O.$$

A similar compound is formed with the arsenates. When the hydrated salt is dried above 130°, it gives ammonium phosphomolybdate, $(NH_4)_3PO_4 12MoO_3$. When the last mentioned compound is treated with aqua regia it forms phosphomolybdic acid, $H_3PO_4 12MoO_3$, a solution of which is an important general reagent for alkaloids. Some compounds of molybdenum and oxygen, which are molybdenum molybdates, have a *blue* colour. The chlorides $MoCl_2$, $MoCl_3$, $MoCl_4$, and $MoCl_5$ are known. The pentachloride is a shining black crystalline solid; melts at 194°; boils at 268°, giving a red vapour; it fumes in air, and is decomposed by water:

$$2MoCl_5 + 3H_2O = MoCl_4 + MoO_3 + 6HCl.$$

The solution becomes blue in air, forming a molybdenyl molybdate, $MoO_2 4MoO_3$. The pentachloride acts as a halogen carrier (*q.v.*) Many oxychlorides are known.—W. H. H.

Molybdic Ochre (*Min.*) A synonym for MOLYBDINE (*q.v.*)

Molybdine (*Min.*) Molybdic oxide, MoO_3. Molybdenum = 65·71; oxygen = 34·29 per cent. Orthorhombic. Usually pulverulent, rarely in fine silky groups. It occurs as a decomposition product of molybdenite, and hence has the same localities.

Moment of a Force (*Phys., etc.*) The product of the amount of a force, by its perpendicular distance from a given point, is called the Moment of the Force about that point. This product is also called TURNING MOMENT *and* TORQUE.

Moment of a Magnet. *See* MAGNET.

Moment of Inertia (*Mech.*) If a particle of mass m be revolving in a circle of radius r, the quantity mr^2 is termed its Moment of Inertia. If a rigid body revolve about any given axis, its Moment of Inertia about that axis is obtained by summing all the separate products $m_1r_1^2$, $m_2r_2^2$, $m_3r_3^2$, etc., where m_1, m_2, etc., are the masses of the separate particles composing the body, and r_1, r_2, etc., are the perpendicular distances of these particles from the axis. The Moments

of Inertia of some solids of common form areas follows, where M is the mass, r the radius :—*Circular Disc:* Axis through centre, $\frac{1}{2}Mr^2$. *Sphere:* Axis through centre, $\frac{2}{5}Mr^2$. *Thin Rod:* Axis through middle, at right angles to rod, $\frac{1}{12}Ml^2$. *Thin Hoop* or *Ring:* Axis through centre, Mr^2. In formulæ for the bending of beams (*see* BEAM) the Moment of Inertia of the cross section is the sum of the products of each element of area into the square of its distance from a given axis. If this axis be through the centre of gravity of the area, and A be this area, we have the Moment of Inertia for a rectangular section equal to $\frac{1}{12}Ah^2$; a triangular section $\frac{1}{18}Ah^2$, and a circular section $\frac{1}{16}Ah^2$: h is the depth of the cross section in the direction along which bending occurs. In beams, I (the Moment of Inertia) must be calculated about the neutral axis (*q.v.*) of the beam, and this may not pass through the centre of gravity of the cross section, but may be at a distance r from it. Then if I_0 be the Moment of Inertia about the axis through the centre of gravity, and I that about the neutral axis, we have $I = I_0 + Ar^2$.

Momentum (*Mech.*) The product of the mass of a body and its velocity. It may be taken as representing the "quantity of motion" of a moving body.

Monad Element (*Chem.*) Same as monovalent element. *See* VALENCY.

Monatomic Molecule (*Chem.*) From Avogadro's Law we have always

$$\text{Vapour density} = \frac{\text{Molecular Weight}}{2}.$$

See MOLECULE. When the vapour densities of mercury, zinc, and cadmium, and iodine at 1,500°, are determined, they give values which are half their atomic weight, from which it is concluded that the atom and molecule of these elements in the gaseous state are identical: they are called monatomic elements. The lowering of the freezing points of many metals, when tin is used as solvent, also yield values for their molecular weights which are identical with their atomic weights. Another kind of evidence is available in the case of mercury and the inert gases argon, helium, etc. The velocity of sound in these gases and in mercury vapour has been found by Kundt's method (*q.v.*) From the observed velocity of sound the ratio of the two specific heats of the gases or mercury vapour can be calculated. *See* VELOCITY OF SOUND. The value for their ratio is 1·66, and this agrees with the value calculated from the kinetic theory of gases for molecules on which no internal work can be done; for instance, no energy of rotation can be imparted to such molecules, nor can they consist of two atoms, for then work could be done in changing their motion about their common centre of gravity; that is, such molecules must consist of single atoms. The ratio of the two specific heats for a gas like hydrogen, which is believed on many chemical grounds to have a diatomic molecule, is 1·41.

Monde (*Her.*) One of the insignia of royalty, consisting of an orb surmounted by a cross, generally pattée. The orb is encircled by a horizontal band, often enriched with gems. *See* CROWN.

Monhydric Alcohol. *See* ALCOHOL.

Monial (*Architect.*) *See* MULLION.

Monk (*Print.*) A black blotch on the printed sheet, caused by a foreign substance in the ink, improper grinding of its materials, or imperfect distribution on the face of the forme

Monkey (*Eng.*) The weight or ram of a pile driver which strikes the head of a PILE (*q.v.*) in order to drive it into the ground.

Monkey Nut. *See* GROUND NUT, PEA NUT.

Monkey Tail (*Carp. and Join.*) A vertical scroll at the end of a handrail.

Mono (*Chem.*) A prefix used in chemistry to denote that the element or group to which it is prefixed occurs only once in the molecule of the compound which bears the name; *e.g.* Monochloracetic acid is acetic acid in which one atom of hydrogen has been replaced by one atom of chlorine.

Monochord (*Sound*). An instrument consisting of a single wire or string stretched on a sounding board between suitable bridges or supports by means of pegs, a spring, or a weight passing over a pulley. Used in experiments on the vibration of strings and in the investigation of the frequency of vibration of other sounding bodies.

Monocotyledones (*Botany*). One of the two subdivisions of the flowering plants. The leaves are parallel veined, the flowers have their parts in threes, and the bundles of the stem are scattered. The subdivision includes the *Liliaceæ*, *Gramineæ*, *Palmæ*, etc.

Monohydric Alcohol (*Chem.*) An alcohol containing only one hydroxyl group. Examples: CH_3CH_2OH . $CH_3 . CHOH . CH_3$. *See* ALCOHOLS.

Monoformin (*Chem.*)

$$\begin{array}{l} CH_2OH \\ | \\ CH_2OH \\ | \\ CH_2OOC.H \end{array}$$

The name given to the ester formed by the union of molecular proportions of glycerine and formic acid, with elimination of one molecule of water. Supposed to be formed when glycerine and oxalic acid are heated together; also when α-chlorhydrin and sodium formate act on each other. On heating the product it yields allyl alcohol—

$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OOCH \end{array} = \begin{array}{l} CH_2OH \\ | \\ CH \\ \| \\ CH_2 \end{array} + CO_2 + H_2O$$

Heated with water, it gives glycerine and formic acid (*q.v.*)

Monolith (*Architect., etc.*) A column, statue, obelisk, or other feature formed out of a single stone.

Monoperipteral or **Monopteral** (*Architect.*) A species of circular temple in which there is neither wall nor cella, but merely columns supporting a roof. *See* PTERA.

Monophase Generator *and* **Motor** (*Elect. Eng.*) A SINGLE PHASE (*q.v.*) machine. *See* MOTORS *and* DYNAMO.

Monophase Motor (*Elect. Eng.*) *See* MOTORS, ELECTRIC.

Mono Rail (*Civil Eng.*) A rail carried on trestles above the level of the ground. The rolling stock either hangs suspended from the rail, as in the Barmen and Elberfeld Railway in Prussia, or else each vehicle is built like panniers, so that it hangs down on both sides of the rail on which it is balanced, as in the Listowel and Ballybunnion Railway in Ireland. In the latter case side rails are added below the level of the main rail to steady the vehicle: they do not sustain any portion of the load.

Monosaccharoses (*Chem.*) A name given to the sugars containing six carbon atoms. *See* SUGARS

Monose (*Chem.*) A name, rarely used now, for sugars containing six carbon atoms. *See* SUGARS.

Monoses *or* **Monosaccharides** (*Chem.*) *See* CARBOHYDRATES.

Monostyle (*Architect.*) A pillar which consists of a single shaft. *See* CLUSTERED PILLAR.

Monotone (*Music*). The recitation of words on one note.

Mono Triglyph (*Architect.*) An arrangement of the Doric frieze and intercolumniation such that there is only one triglyph between the triglyphs immediately over two adjacent columns. This is the usual arrangement. *See* TRIGLYPH, DI-TRIGYLPH, TRI-TRIGLYPH, ARCHITECTURE, ORDERS OF, *and* ENTABLATURE.

Monovalent Element *or* **Group** (*Chem.*) *See* VALENCY.

Monsoons (*Meteorol.*) Prevailing winds in Southern Asia. North of the Equator they are S.W. winds, lasting from about May to October; and south of the Equator they are N.W. winds during the remainder of the year. The S.W. monsoon is followed during the rest of the year by the N.E. trade wind, and the N.W. monsoon by the S.E. trade wind.

Month, Sidereal (*Astron.*) The time it takes the moon to make her revolution from a given star to the same star again, as seen from the centre of the earth. Its mean value is 27d. 7h. 43m. 11·55s.

——, Synodic (*Astron.*) The time between two successive conjunctions or oppositions, *i.e.* between successive new or full moons. Its mean value is 29d. 12h. 44m. 2·86s.

Monumental Brasses. *See* BRASSES, MONUMENTAL.

Moon (*Astron.*) A satellite of the earth, and to us, ranking next to the sun as the most important of the heavenly bodies. The mean distance from the earth is 238,840 miles; mean diameter, 2,163 miles. The passage of the moon between the earth and the sun, near the nodes, causes eclipses of the sun which are partial, annular, or total, according as the conditions prevail.

Moonstone (*Min.*) A variety of ADULARIA which is a colourless semitransparent variety of Orthoclase Felspar. *See* ORTHOCLASE. Moonstone has a pearly lustre, and is used as an ornamental stone. Suitable specimens come chiefly from Ceylon and other localities in the East Indies.

Moor Cock (*Her.*) A charge: the male or cock bird of red grouse.

Moorish Architecture. This is a branch of Mohammedan architecture, and was originally developed in Northern Africa around Morocco; but the finest examples were produced in Spain, which was under Moorish rule from 710—1492 A.D. The principal features of Moorish work are slender columns; semicircular, horseshoe, and cusped arches, and minarets, which in Spain were replaced by massive towers. The richly coloured interiors were treated with minute surface ornament, tiling, plaster relief, and pierced work, the ornament being usually of geometric type and embodying inscriptions. The most noteworthy examples are the Alhambra at Granada (begun 1248 A.D.), the Alcazars at Seville and Malaga (thirteenth century), the Giralda at Seville, and the Great Mosque at Cordova (begun 786 A.D.)

Moor's Head (*Her.*) A charge representing a negro's head in profile, generally with a pearl ear pendant.

Mopstick Rail (*Join.*) A handrail of circular section.

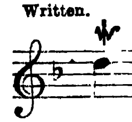
Moraceæ (*Botany*). A Dicotyledon order of trees and shrubs, including the mulberry, fig, hop, etc. This order yields fruits, fibres, rubber, drugs, and timber.

Moraines (*Geol.*) The loose piles of stones and other rock *débris* which are carried outward from the heart of a mountain area by the agency of glaciers. They naturally form three types: (1) Those which have fallen from the slopes above the side of a glacier and form the lateral moraine. (2) Those which find their way to the middle of the surface where two lateral moraines unite into one. (3) The terminal moraine, which represents the *débris* left at the outer end of a glacier. A fourth kind is supposed by some to exist beneath the glacier, and this supposititious material is referred to as the "Moraine Profonde."

Mordants. *See* DYES AND DYEING.

Mordente (*Music*).—Of the musical ornaments or grace notes, this is one of the most important. Mordentes are of two kinds, the Short and the Long, and are written and played as follows:

Written. SHORT MORDENTE. Played.



LONG MORDENTE.

Besides these there is the inverted mordente or pralltriller, which has no upright line through the sign, *e.g.*

Written. Played.

This inverted mordente is also called a "Schneller."

Moreau Marble. *See* ARTIFICIAL STONE.

Morendo (*Music*). Dying away, *i.e.* gradually getting softer and slower.

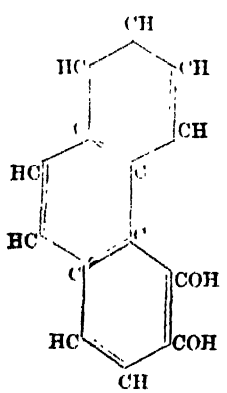
Morion, Morian, *or* **Murrion** (*Arm.*) A Moorish headpiece or helmet copied by the Spaniards about the middle of the sixteenth century, and worn later by other European nations also. The crown of the earlier morions was pointed in shape, the brim, both before and behind, forming a peak, which canted upwards; later the crown was rounded in outline and often surmounted by a crest or comb. The morion was worn as late as Cromwell's time.

Morning Star (*Astron.*) A star which rises just before the sun, in contradistinction to an evening star, which sets just after the sun.

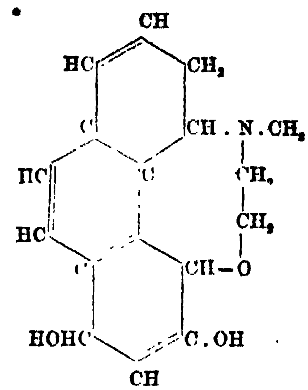
Morocco (*Leather Manufac.*) Tanned goatskins used for furniture and the highest class of bookbinding leather. It was formerly obtained from the African town after which it is named.

Morphine *or* **Morphia** (*Chem.*) An alkaloid. White crystals, needles or prisms, containing one molecule of water of crystallisation; melts with decomposition at 230°; sparingly soluble in water (about 1 in 10,000 at ordinary temperature and 1 in

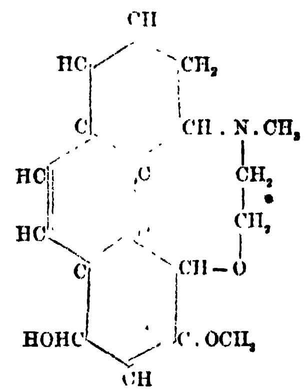
450 boiling); more soluble in alcohol (5 in 100 at ordinary temperature); soluble in warm amyl alcohol; nearly insoluble in ether and benzene. It is lævorotatory. Morphine is a strong base, and forms many salts. The hydrochloride, $B . HCl . 3H_2O$, silky needles, soluble in water; the tartrate, $B_2 . C_4H_6O_6 . 3H_2O$, small white crystals, soluble in water; the acetate, $B . C_2H_4O_2 . 3H_2O$, white crystals, readily soluble in water, are all used in medicine, but the acetate not so much as the other salts, because it loses acetic acid and becomes less soluble. (B stands for morphine.) Morphine occurs in opium, Smyrna-opium containing most of the alkaloid (11·7 to 21·5 per cent.) The opium is thoroughly extracted with warm water, the solution neutralised with calcium carbonate and concentrated; calcium chloride is now added to precipitate meconic acid, and the solution is evaporated to a syrup, when it deposits crystals of morphine and codeine hydrochlorides, which are recrystallised; from the solution of the mixed hydrochlorides ammonia precipitates morphine only. The following reactions are important in the determination of the constitution of morphine. Analysis shows it to have the formula $C_{17}H_{19}NO_3$. It is a phenol because it gives a blue colour with ferric chloride, and combines with caustic soda to form a salt in which one hydrogen is replaced by sodium. It contains another hydroxyl group besides the phenolic one, for it yields both a monoacetyl and a diacetyl derivative with acetic anhydride. The diacetyl morphine is used in medicine under the name heroine. It is a tertiary base because it unites directly with methyl iodide, and the addition product can be converted into a hydroxide. On warming morphine with methyl iodide in presence of sodium ethoxide, codeine (which is methyl morphine) is obtained. Codeine unites directly with methyl iodide to form codeine methiodide, and this compound yields a hydroxide with moist silver oxide. Codeine methyl hydroxide readily loses water, and forms a white crystalline solid called methylmorphimethine, which has the following important reaction: Heated in a sealed tube with acetic anhydride at 160° to 200°, it yields an isomeric compound, and also oxyethyldimethylamine and an acetate of oxymethoxyphenanthrene. The dehydroxyphenanthrene from which the last mentioned compound is derived is called morphol, and it has been synthesised. It has the constitution:



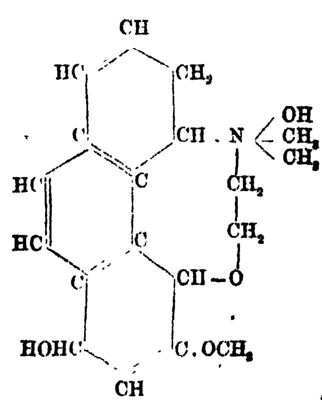
When morphine is heated with zinc dust, phenanthrene is among the products of its decomposition. On these grounds the following formula has been assigned to morphine:



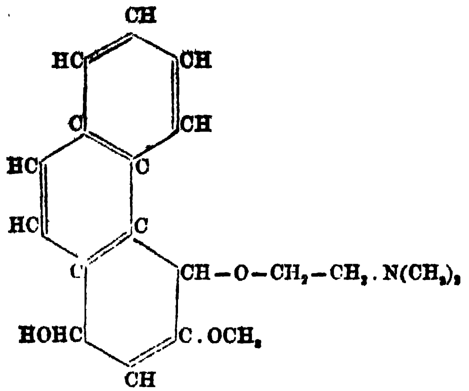
Accordingly the derivatives mentioned will be represented as follows:



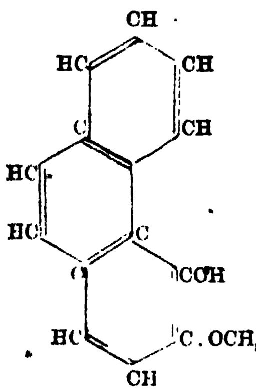
Codeine.



Codeine Methyl Hydroxide.



Methylmorphimethine.



Oxymethoxyphenanthrene (Methylmorphol).

$$HO.CH_2.CH_2.N(CH_3)_2.$$

Oxyethyldimethylamine.

When morphine is heated with concentrated hydrochloric acid it loses one molecule of water, and forms apomorphine, a white amorphous powder which turns green in air; it is used in medicine because it is a powerful emetic. Phosphorus trichloride replaces the alcoholic hydroxyl by chlorine, forming a compound called chlormorphide, $C_{17}H_{18}NO_2Cl$, and this on treatment with water yields two compounds isomeric with morphine, called isomorphine and β-isomorphine; but these compounds have not the narcotic properties of morphine. Morphine acts as a reducing agent, and on this property most of the tests for it are founded, *e.g.* the liberation of iodine from iodic acid. The alkaloid (its salts) are used in medicine for producing sleep and relieving pain; it is very poisonous.—W. H. H.

Morrow Clutch (*Cycles*). A form of friction clutch in which the contact is made by a series of rollers running on slightly inclined teeth, resembling a ratchet wheel. The rollers serve as pauls when the free wheel is driving the cycle; when the pedals are still, the rollers drop back and release the outer ring of the chain wheel.

Morse (*Cost.*) A clasp, often richly engraved, by which a cope is fastened.

Morse Code *or* **Alphabet.** The alphabet in which every letter is represented by a combination of two elementary symbols: in writing, these symbols consist of a dot and a dash; in telegraphic or other signalling the movement of a needle, pointer, flag, etc., to one side represents a dot, and to the other side, a dash. By this means a complete system of transmitting messages can be used with apparatus which is capable of giving two distinct signals only.

Morse Receiver *or* **Recorder** (*Elect. Eng.*) A telegraphic instrument which records the dots and dashes of the Morse Code on a strip of paper which is drawn off a drum. The current received by the instrument acts on an electro magnet which moves an arm provided with a marking point or wheel; this marker comes in contact with the paper strip, and produces a dot or a dash according to the duration of the current.

Mortar. *See* CEMENTS.

Mortar Mill (*Build., etc.*) A grinding and mixing mill for mortar; it consists of two cast iron wheels or rollers, running on the ends of a short horizontal axis which is fixed to a vertical rotating axis. The rollers are thus caused to run round a circular track in a shallow pan in which the lime, sand, etc., are placed. *See* EDGE RUNNER.

Mortice (*Carp.*) A hole, usually rectangular, cut to receive a TENON (*q.v.*) A mortice usually passes right through the piece of wood in which it is cut.

Mortice Chisel (*Carp. and Join.*) A chisel with a very strong blade and a handle adapted for receiving blows from a mallet. Used in cutting a mortice (*q.v.*)

Mortice Gauge (*Carp. and Join.*) A gauge formed by a bar, along which slides a guide or fence which can be fixed at any required point on the bar. Near one end of the latter are two metal points projecting at right angles to the bar; one point is fixed, the other can be adjusted at any required distance from the first one. Used for marking two lines simultaneously, parallel to the edge of a piece of wood, as in setting out a mortice (*q.v.*)

Mortice Machine (*Carp. and Join.*) A machine having a chisel attached to a massive tool holder, which can be raised or depressed by a lever. The tool holder moves vertically in guides attached to the frame of the machine. The wood to be cut rests on a table which can be given a lateral motion by means of a wheel turned by hand; after each stroke or cut of the chisel, the wheel is turned slightly, to move the wood into a suitable position for the next cut to be taken. The machine is now almost universally used for cutting mortices, even in small workshops.

Mortice Wheel (*Eng.*) A gear wheel in which the teeth are formed of wood, each tooth being driven into a mortice or socket in the rim of the wheel; once very common in mill work.

Mortier (*Her.*) A cap of estate, worn by the French Chancellors and Presidents of Parliament; used as a charge in French heraldry.

Mortise (*Carp. and Join.*) *See* MORTICE.

Mosaic (*Architect.*) Inlaid work formed of small pieces, usually cubes, of marble, glass, or other

materials. It is used as a decorative treatment of floors and wall surfaces. *See also* BYZANTINE.

Mosaic Gold (*Chem.*) Stannic sulphide. *See* TIN COMPOUNDS.

Moss Agate (*Min.*) A variety of CHALCEDONY (*q.v.*) containing dendritic forms of Limonite or Pyrolusite, which coat the surface of cracks within the agates. *See also* AGATE.

Mosso (*Music*). Movement.

Motes (*Cotton Manufac.*) Spots on spun yarn due to crushed seed or leaf which has not been freed from the cotton fibre during the spinning processes.

Mother Liquor (*Chem.*) The liquid remaining when a solution of a substance or mixture of substances has been caused to deposit crystals.

Mother of Coal (*Geol.*) *See* COAL.

Mother of Pearl. The inner layer of the shell of many bivalve molluscs, particularly the pearl oyster. This substance is used in ornamental work.

Mother of Vinegar. *See* ACETIC ACID.

Motion (*Lace Manufac.*) One movement of the carriages from back to front or *vice versâ*, like the swing of a pendulum from right to left or *vice versâ*. In most machines it is one revolution of the front shaft.

Motion Bars (*Eng.*) The SLIDE BARS or GUIDE BARS of an engine (*q.v.*)

Motion Block (*Eng.*) A SLIDE BLOCK (*q.v.*)

Motion in Line of Sight (*Astron.*) The motion of bodies in space can be resolved in two directions, either in the line of sight or at right angles to this direction. The former can be measured by the spectroscope.

Motion Work (*Clocks and Watches*). The short train of wheels used between the hour and minute hands to maintain their relative speeds. *See* CANNON PINION.

Motor. A general term for a prime mover or engine; applied especially to electric motors (machines for converting electrical energy into mechanical energy) and to petrol and spirit motors (*q.v.*) Also a contraction for MOTOR CAR.

Motor Boats and Launches.—The term "Motor Boat" is now usually applied to small vessels propelled by an internal combustion engine using petrol or some similar oil or spirit. The engine of such a boat is of some standard type, such as is described under PETROL ENGINE (*q.v.*) In certain cases an engine with a two stroke cycle is employed, as its lower speed is advantageous when the engine is connected directly to the shaft of the propeller. As a petrol engine cannot be reversed when the boat is required to go astern, the propeller is often made "reversible"; the blades can be moved in such a way as to reverse the direction of the screw (*i.e.* from right handed to left handed). The necessary movement is effected by a lever in the boat, connected by a rod to a sleeve on the hub or boss of the propeller. The average size of the boats now in use is about 25 ft. in length, and 5 ft. to 6 ft. in beam, the horse power commonly being from 10 to 15; but boats have already been built of 150 horse power. The Delahaye boat may be quoted as an example. The whole of the engine, working parts, control lever, etc., are carried on a single bed plate, so that, the bottom of the boat having been prepared, it drops into place without elaborate bolting or fitting, and the whole can be easily inspected. The 12 h.p. two cylinder engine has cylinders of 100 mm. bore by 140 mm. stroke, making 1,150 revolutions per minute. The Napier is the best known of the English made engines, and it has already proved as effective on the water as on land. Great interest was evoked in motor boats by the International Race from Calais to Dover on August 8th, 1904. Out of twenty-one starters twenty finished: *Mercedes IV.* (80 h.p.) winning in about a minute over the hour; *Napier* (73 h.p.), some 5½ minutes behind, second. The leaders travelled over 22 knots per hour, and the little *Princesse Elizabeth*, only 30 ft. keel and 45 h.p., easily held the finest and fastest cross Channel boat of the day, the turbine-driven *Queen* (about 300 ft., with 5,000 h.p.), in mid Channel. In October, 1904, in a race between a boat of 40 ft. length and 90 h.p. and another of 37 ft. and 150 h.p., from New York to Albany and back (about 275 miles), the former won, maintaining an average speed for the whole journey of 26·29 miles per hour, a pace excelled by very few "destroyers." These figures seem to indicate that there is a great future for the motor boat.

Motor Cars. The term "Motor Car" is used somewhat loosely, and although in England it is taken to comprise all classes of self propelled goods or passenger vehicles which are adapted to run on ordinary roads, in the United States of America the term is, and has been for many years, employed in connection with tramcars. It is the former or purely British sense that is here adopted, and without attempting a definition that would fully differentiate between what *is* and what *is not* a motor car, it may be briefly stated in general terms that all self propelled vehicles adapted to run, and be steered, on common roads, and to carry either goods or passengers, other than exclusively for their own consumption or guidance, fall within the meaning contemplated. HISTORICAL: The history of the motor car has its origin in the earliest attempts at mechanical traction, and consequently goes back prior to the commencement of the nineteenth century. With these early attempts are associated the names and work of Cugnot (1770), Trevethick (1802), and during a period of phenomenal activity (1825 to 1835) of Hancock, Gurney, Summer, Ogle, and others. The successes achieved by both Hancock and Gurney are such as to suggest that under more favourable circumstances the development of mechanical traction on common roads would have become a matter of steady progress and growth, instead of being doomed to premature extinction, resulting in the almost total loss of the experience and information that had been gained. The railway locomotive, although taking its origin in the same cradle as the steam carriage, proved itself an infant of much more rapid growth. The conditions under which it is required to work being less exacting, success proved to be within more easily attainable reach. From the time of the abandonment of the early steam carriage (about 1840) to that of what may be aptly termed the "Motor Car Renaissance," sporadic efforts were made, and more or less successful results were achieved. Notable amongst these were vehicles by Ricketts (who built a series from about 1858 onwards), Yarrow (1862), Holt (1867), and others. In general, considering the enormously

increased facilities provided by the then modern machine shop, the results achieved during this period were disappointing, especially when compared with the previous efforts thirty years earlier with comparatively crude appliances. It is doubtful whether the weights of engine achieved per horse power was any great advance on Hancock or Gurney, and although in some cases the engine was geared down considerably on to the road wheels as on a modern car, the extent to which this was done (taking into account the slow car speed) was not sufficient to fully realise the advantages of the high speed engine, and thus where gearing was used the advantage obtained was scarcely sufficient to justify its employment. The cars of this period embodied little more than the bare necessities of locomotion, and no attempt was made to build steam carriages in the sense understood by Hancock and Gurney, or motor cars, as they are understood to-day. These sporadic efforts are unimportant historically, as they show no continuity either with the past efforts or with the subsequent history of the development of the modern car. The present era in the history of the motor car was inaugurated by the employment about the year 1885 of the internal combustion engine as the means of propulsion. For this innovation the credit must be given to Gotleib Daimler, who, while adhering to the Otto or four stroke cycle (which had driven all competitors from the field in the gas engine world), succeeded, by adopting high speed, in producing engines of very light weight for the power developed, and so rendering the internal combustion engine suitable for the propulsion of motor vehicles. Of the firms early in the field, the most successful to apply the Daimler engine to the propulsion of the motor car was undoubtedly that of Panhard & Levassor, whose general arrangement of mechanism and system of change gear and transmission, subsequently adopted by many of the leading makers, survives at the present day. The practical solution of the problem by the application of the internal combustion, or, as it is somewhat loosely termed, the "petrol" engine, and the publicity given by the races and competitions that were organised from about the year 1894, had the result of stimulating effort in other directions. Not only did the makers of these cars increase rapidly from year to year, but several firms commenced the manufacture of steam driven cars, in a few cases (notably Serpollet in France, and the "Stanley" or "Locomobile" in the United States of America) as a direct competitor with the light petroleum spirit car; but steam was more generally and successfully employed in cars for heavy traffic with a "tare" of about two tons and upwards. Owing to the development of the industry the term "petrol car" needs definition. Since petrol was the first suitable light petroleum distillate available as a fuel for internal combustion engines, the name became associated with the cars, in contradistinction to steam, gas driven, or electric cars; but really it is a misnomer for petroleum spirit or light hydrocarbon cars. There are now many suitable petroleum spirit fuels for cars propelled by internal combustion engines, but there is a tendency to retain the old title. The limitations of the term petrol instead of petroleum spirit cars are as misleading, as designating cars driven by alcohol motors, "brandy" or "gin" cars, instead of alcohol cars. The Electrical (Accumulator) Motor Car also made its commercial appearance under the stimulating influence of the success achieved by the petroleum spirit vehicle. The claims put forward on behalf of electrical propulsion proved to rest on but slender foundation. The electric accumulator was never able to hold its own against the internal combustion engine or even the steam engine, owing mainly to the cost of up-keep and weight of accumulators necessary per horse power hour. The useful range of the electric vehicle being limited by this latter consideration to about twenty miles out and home, its employment has been confined to short distance work in populous cities. So long as lead oxide is the means of electrical storage there is no prospect of the electrical vehicle seriously improving its position.

TYPES OF MODERN CAR: The various types of modern motor car may be roughly classed as:

MOTOR CYCLES, including all small vehicles built on cycle lines with the motor and frame resting directly on the road wheel axles without "suspension."

Subdivisions:

Motor Bicycles: generally having accommodation for one.

Motor Tricycles: generally arranged with accommodation for two.

Motor Quadricycles: generally arranged with accommodation for two. *See also* MOTOR CYCLES.

MOTOR CARS (so called), including all types of suspended passenger vehicle, and classifiable roughly as follows:

Voiturettes: generally having accommodation for two, with sometimes additional accommodation.

Light Cars: usually built to accommodate four.

Touring Cars: long distance vehicles to accommodate four upwards.

Motor Broughams, *Motor Landaulets*, *Motor Wagonettes*, *etc.* — arranged with accommodation, etc., as their names would indicate. Body work following horse drawn practice.

HEAVY MOTOR VEHICLES, including slow moving vehicles primarily for goods transport usually (at present constructed) upwards of two tons "tare." Types of this class are not as yet fully differentiated; but the steam lorry or dray is at present the principal type.

It may be noted that two types of self-propelled road vehicles, the steam road-roller and the traction engine, are not included in our definition. The popular types of vehicle of the cycle and car classes are subject largely to the influence of fashion, based on, but not altogether proportioned to, the apparent merits of the types of the moment. The "vogue" in motor cycles until about the year 1900 favoured the three wheeled machine, the type then most common being the "De Dion." Since that date the motor bicycle has come into more general use, and is the almost universal one seat machine of to-day, the "quad" and the more modern form of tricycle with fore carriage being the more popular of the two seated arrangements. The most notable effect of fashion in the car class of vehicle has been the vogue until about a year ago (1903) for the rear entrance "tonneau," and the present reaction in favour of the side entrance car. The essential functional elements of a modern petroleum spirit motor car are as follows: Commencing at the fuel tank, we have: (*a*) The VAPOURISER, in which the liquid fuel is vapourised and mingled with air to form an explosive mixture. (*b*) The ENGINE or motor by which the explosive mixture is drawn from the vapouriser, compressed, ignited, expanded, and the products of combustion expelled, and by which as great a proportion as possible of the energy contained in the vapourised fuel is converted into power; and,

subsidiary to the engine, the **Cooler** (or **Radiator**) and **Exhaust Silencer**, by which the waste heat and products from the engine are dissipated and discharged into the atmosphere. (*c*) The **Clutch**, by which the employment of the power of the engine is controlled. (*d*) The **Change Gear**, by which the relation between the speeds of driving and driven mechanism may be accommodated to suit change of gradient (fig. 1). (*e*) **Transmission Train**, by which

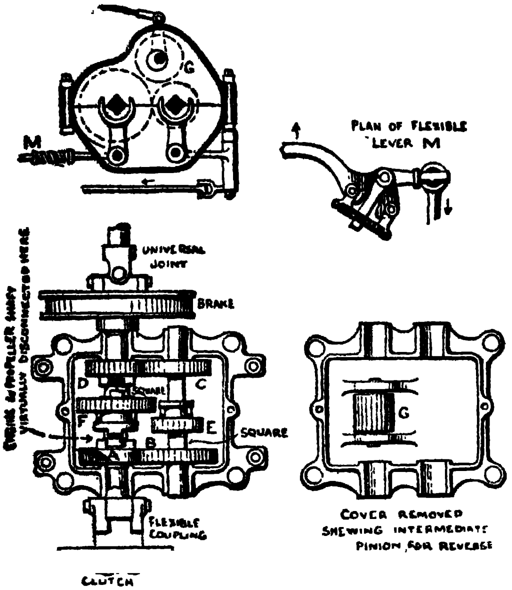


Fig. 1.—The "Argyle" Gear Box.

the power is conveyed to the road wheels (fig. 2). (*f*) The **Tyres**. The functional elements of the steam car are in the main analogous, and to some

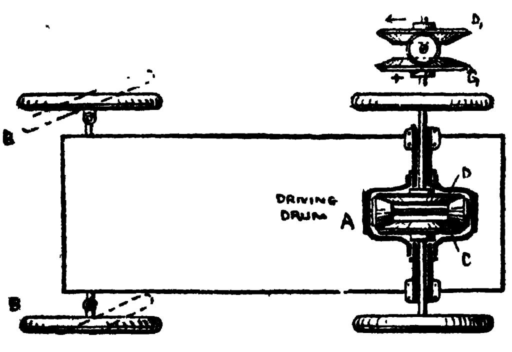


Fig. 2.

extent identical; but the clutch and change gear are dispensed with, the condenser takes the place of the cooler, and the boiler is additional. The vapouriser commonly employed is of the "spray" type, and works on the same principle as the common spray diffuser; it is arranged in the suction pipe of the engine. In another form of vapouriser the petrol is sucked up by numerous wicks into chamber through which the air passes on its way to the motor, and is thereby saturated with vapour. The motor almost universally employed works on the well known "Beau de Rochas" or "Otto" principle, in which the complete cycle of operations occupies four strokes of the piston, these being respectively: (1) suction, during which the admission valve is open; (2) compression, during which the gases taken in on the previous stroke are compressed; (3) the expansion, in which the gases after ignition expand, doing work; and (4) the exhaust, during which the waste products are expelled through an exhaust valve. The number of cylinders in common use varies from one in the cheaper class of car to four in the better class of touring car, and in machines specially built for racing. The advantages of the multicylinder engine are the absence of vibration and the greater uniformity of "torque." The advantages claimed for the single cylinder engine are simplicity and cheapness. Great efforts have been made to produce a balanced engine in which there is no vibration. In the generality of cars the engine is of the vertical type, though in some standard types of car the horizontal engine has been employed, owing to its greater suitability to the design. The coolers or radiators are of various designs, the object being in all cases to present as great a hot surface to the surrounding air as possible. Radiators are sometimes assisted by a fan to blow or suck air over the hot surfaces, and the water circulation is usually maintained by a pump. In some engines direct air cooling has been employed, in which air is blown over gills attached direct to the cylinder. Clutches for the control of the power transmission are of various forms. The majority at the present day are conical clutches, leather faced. An advance on this practice is found in the metal on metal clutches of the "Mercedes," "Lanchester," and "Hele-Shaw" types. The former is a coil clutch and the two latter are conical, the "Hele-Shaw" being an application of the multiple disc (or Weston) principle. The change gear most commonly employed at the present day is that of intermeshing toothed wheels, a series of toothed gears on a sliding sleeve being arranged to successively mesh with a corresponding series on the driven shaft. Another form of gear used by a number of makers is the "Sun and Planet," or epicyclic change gear—a type which offers many advantages, and which probably has a great future before it. There are three main types of power transmission in common use: *the parallel drive*, in which the axes of motor shaft, counter shaft, and road wheels are parallel and connected by ordinary spur gearing or by chains; *the "Panhard" type*, in which the motor shaft is at right angles to the road wheel axle, and the transmission is effected first by a bevel drive on a sprocket shaft, and then by chain drive to the road wheels (fig. 3 and fig. 4); and the *direct right angle drive*, in which the motor is arranged as on the "Panhard" system, but the bevel drive is located on the road wheel axle, and the transmission carried across the suspension by a jointed coupling shaft (fig. 5). A variation in this system is the now well known worm drive. Pneumatic tyres are almost universally used on the passenger types of car. *See* **Tyres**. The only features of a steam car to which special allusion need be made are the petroleum burner and boiler. The petroleum burner in principle is extremely simple, the oil being led through a pipe or tortuous passage heated by the burner itself, whereby the oil is gasified. It then passes to the burner nozzle, where it escapes under pressure, and, mixing with the air necessary for its complete combustion, passes into the burner proper, where the combustion,

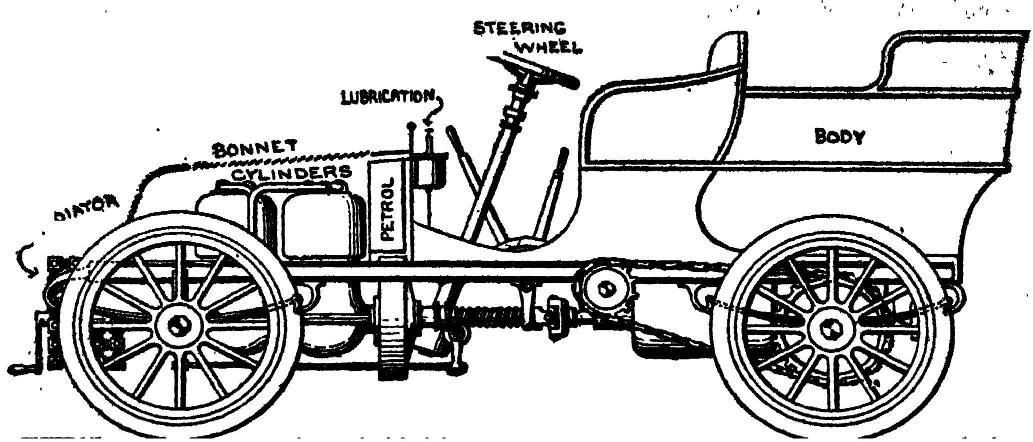


Fig. 3.—Chain Driven Motor Car (Elevation).

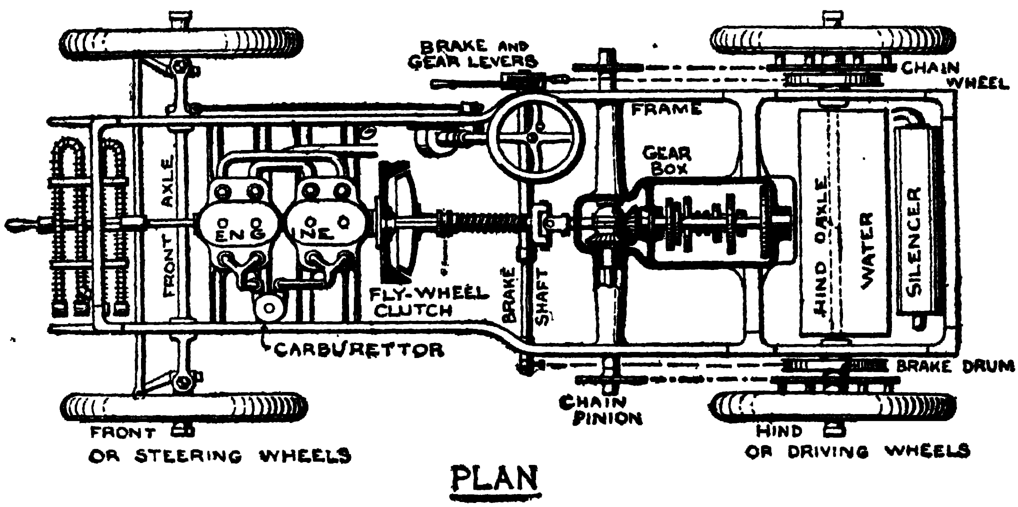


Fig. 4.—Chain Driven Motor Car.

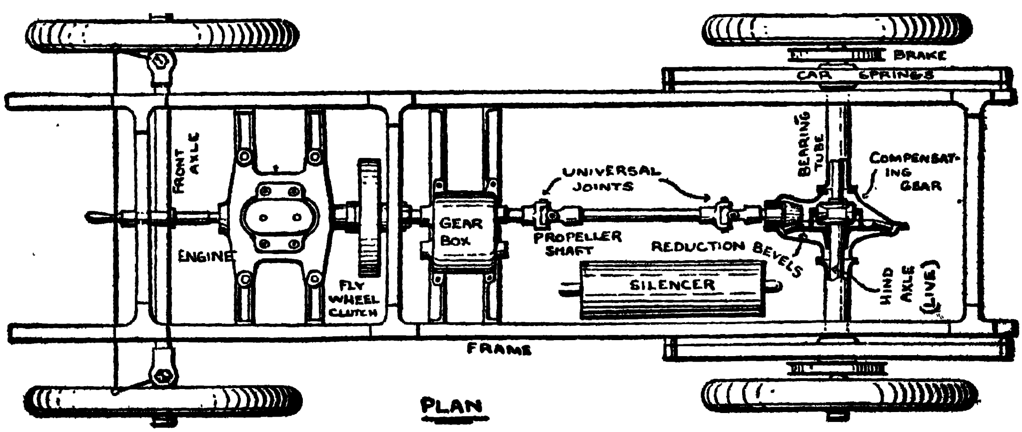


Fig. 5.—A Chainless Motor Car.

if perfect, takes place with a blue flame, as in the ordinary Bunsen or atmospheric gas burner. The steam boilers in use consist in the main of two classes. The ordinary boiler is of the multitubular "*fire tube*" type, and is commonly arranged with vertical tubes, the boiler shell consisting of a cylindrical drum, the ends of the cylinder forming the tube plates. The "Locomobile" boiler may be taken as typical. Special designs of "*water tube*" boiler also are employed. Another boiler of considerable promise is the type known as the "flash" boiler, consisting of a tube of great length and very small capacity, in which the water is converted into steam as fast as it is injected. In these boilers the production of steam is controlled by cutting off or turning on the supply of water to the boiler, simultaneous control being exercised on the burner by which it is heated. The "Serpollet" may be taken as typical of this class, of which it is unquestionably the leading representative. *See* BOILERS. In all types of vehicle an efficient brake is a vital necessity. The only satisfactory forms of brake have metal on metal friction surfaces, an exception being the tyre brakes of slow moving heavy vehicles, where wood blocks are successfully employed. The most generally used classes of brake are the internal and external varieties of band brake on drums fitted to the road wheels; the lever and block brakes, and cone brakes, as fitted to the transmission shaft (fig. 6); also certain disc varieties are sometimes employed. The particular type of brake is not so important as its soundness of design and material. Under the Light Locomotives Act all cars must be fitted with two independent brakes, and this has become the universal practice. Some makers advocate the fitting of a third or reserve brake, but this is quite unnecessary on a well constructed machine.

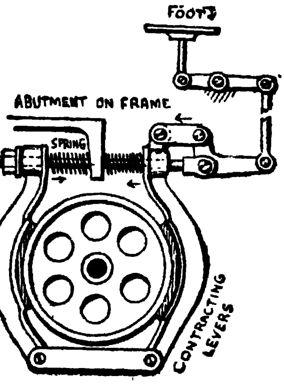
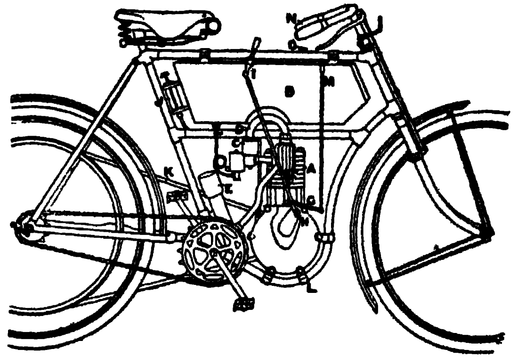


FIG. 6.—THE "ALBION" PROPELLER SHAFT BRAKE.

Motor Cycles. The main parts of a typical motor bicycle are clearly shown in the illustration (given by permission of the Temple Press). The frame in this case is somewhat different from that of an ordinary bicycle, but in certain types of machine the form of the latter is adhered to more closely. In all cases, however, the whole structure (frame, wheels, tyres, brake, etc.) is greatly strengthened by means of heavier tubing and lugs, the front forks and head being provided with additional members, if necessary. The back forks are made sufficiently wide to allow of the addition of a driving rim and to provide clearance for the belt K, by which the power is conveyed from the pulley on the axle of the engine to the back wheel. With these exceptions the machine follows the type of the ordinary cycle. The engine itself is a single cylinder petrol engine of ordinary type. *See* PETROL ENGINE. A is the cylinder, bolted to the crank chamber, which is secured by lugs L to the frame. Above the engine is placed a case B, which contains a tank for the petrol, another for lubricating oil, and a compartment for the accumulators and induction coil. Petrol flows from the tank through a tube of narrow bore to the SPRAY CARBURETTOR (*q.v.*) C;



MOTOR CYCLE.

A, Cylinder.
B, Tanks.
C, Carburettor.
D, Inlet Pipe.
E, Silencer.
F, Exhaust Valve Chamber.
G, Exhaust Lifter.
H, Contact Breaker.
I, Lever for advancing the spark.
J, Pump for lubricating oil.
K, Driving Belt.
L, Lugs.
M, Rod for lifting exhaust valve.
N, Handle Switch.
O, Plug Switch.

from this tube the gas flows through the pipe D, and enters the cylinder by an INLET VALVE (not visible in the figure). The exhaust gases (products of combustion) leave the cylinder by an EXHAUST VALVE in the chamber F, and pass through another pipe to the SILENCER E. The exhaust valve can be lifted when required by a lever G, actuated by a rod M. The current flowing through the primary of the induction coil is interrupted by a CONTACT BREAKER in the chamber H; this contact breaker is actuated by the HALF SPEED SHAFT. The time at which the spark occurs can be controlled within certain limits by "advancing the spark"; this operation is effected by turning the contact breaker through an angle by means of the lever and rod I. Lubricating oil is supplied to the engine when required by means of a small pump J, worked by hand. The engine can be stopped by cutting off the current entirely; for this purpose two SWITCHES are included in the primary circuit: one is usually contained in a handle N of the machine, and is operated by turning the handle half round; the other is a PLUG SWITCH O, which is closed by the insertion of a small brass plug, easily carried in the pocket when the rider has dismounted, and wishes to ensure that the current from the accumulators is not wasted or the current improperly started. The details and method of action of the engine are dealt with under GAS ENGINE, OIL ENGINE, and PETROL ENGINE; but the principles involved may be summarised as follows:—A supply of petrol sufficient for one charge is drawn into the CARBURETTOR C, where it is volatilised and mixed with air to form an explosive vapour, and is drawn into the cylinder chamber, which it fills as the piston descends. On the piston rising both valves close, and, there being no escape, the "mixture" (as the air and petrol vapour is termed) is highly compressed, *i.e.* to a third or quarter of its original volume. At this point it is fired by the SPARKING PLUG, the vital "heart" of the machine. This emits the spark which fires the

charge (internal explosion), and gives motion to the whole machine by the explosive power thereby exercised. The sparking plug is a porcelain cylinder or tube surrounded by a metal sleeve nut, which makes a gas tight joint; the connecting wire passes through the plug, the sparking joint being within the explosion chamber. At the outer or flat end the end of the wire is bent at right angles, and at $\frac{1}{32}$ of an inch from it is a corresponding wire connected with the metal shell, and therefore with the frame of the machine which is used to convey the return circuit. The spark jumps over the small space between the joints. On the side of the engine opposite to the pulley is a short shaft, the half speed shaft, rotating at one half the speed of the crank shaft. This operates the exhaust valve (or exhaust and inlet valves) and also the contact breaker, an electrical device which is made in various patterns, but mainly of either WIPE or MAKE AND BREAK contact. It consists of a very small, light, flexible steel spring. Midway there is a tiny platinum disc; on the other end either a V projection or other device to engage the eccentric of the revolving cam. Above the disc is a corresponding platinum stud at the end of a screw, which forms the terminal of the electric wire. The spring vibrates at high speed; each time the discs are separated the current is broken, and the spark thereby produced within the cylinder. When the explosion has driven the piston to the bottom of the cylinder, the inlet valve closes, and the exhaust valve opens. The spent gas is swept out as the piston rises. The chamber is now empty, the piston descends, the exhaust valve closes, the inlet valve opens, and the next charge is sucked through the carburettor into the chamber. The piston now rises again, and the gas is compressed; the charge is fired, and so the process goes on at the high rate of 1,500 to 2,000 revolutions of the engine per minute—two revolutions (four motions) to each explosion. The spent gas passes from the exhaust valve into the silencer, a chamber which serves to deaden the sound. Without this device—*i.e.* with a "free port" to the exhaust valve—the noise created by the explosions would be deafening. There are many forms of silencer: in most of them the burnt gas is discharged close to the ground. MAGNETO IGNITION is an alternative system of firing the charge; the current is produced from the engine by a small magneto machine (a simple form of dynamo with permanent field magnets). A special form of sparking plug is used in the "low tension" system, as this method of ignition is termed. The device causes noise and friction, and uses up energy; but neither coil nor battery is needed. HORSE POWER (expressed h.p.) varies considerably: 1¾ h.p. is the standard for ordinary roadster touring single bicycles, but 2 to 2½ and even higher powers are used by expert riders. High power means great speed, more danger, and greater cost. The TRICARS, where permanent provision is made for a passenger, and perhaps luggage, generally have 3 h.p. On the path, for pacing in races, French riders use 10, 12, and even 14 h.p. on a single or tandem bicycle. The ENGINE, although generally vertical, is sometimes placed at various angles, or even horizontally, as the maker considers most effective. The DRIVING POWER may be communicated in several ways: (1) Belt. (2) Chain. (3) Gear. The belt is either: (*a*) flat leather strap; (*b*) twisted hide, which can be further twisted to tighten; or (*c*) a V built up and flat bottomed, so as to better grip the V or U pulley. The CHAIN is not nearly so much used as the belt, but is increasing in favour. The GEAR DRIVE is being introduced in some cases: the power is transmitted from the engine through gearing somewhat analogous to that used in motor cars. GEARING DOWN: Owing to the high speed of the engine, the driving is from a small pulley on the motor axle to a pulley four, five, or six times the size, otherwise the speed would be too great. In racers the ratio is reduced from one to two and a half. Some machines (such as the Bat) have no pedals, and the rider is dependent entirely on his engine. In most cases, however, pedals (always "free wheel") are employed, and are useful in helping the motor up a stiff hill, or for exercise when the rider has become cold or cramped. Lubrication is effected by the small pump J, above mentioned, placed within easy reach of the rider. Only a special and heavy product of vaseline for air cooled motors can be used; an ordinary oil would be burnt up by the great heat. A few strokes of the pump force the lubricant into the crank case and other required points. The electric current should be frequently tested and the battery recharged, as if it runs out the rider is helpless. Indeed, the three non-mechanical essentials—the battery, the petrol supply, and the lubricant—should be carefully watched. VIBRATION is the great drawback of motor cycling. A much larger and easier saddle is required than in the case of the ordinary cycle. Spring saddle pillars have been introduced; in the Bat the seat pillar is isolated from the machine by coil springs, with resultant comfort to the rider. The handle bars communicate great vibration, to obviate which the Quadrant Company fit a most effective double fork, which absorbs a great portion of the vibration, the consequence being that the arms and hands do not get tired, as with a rigid machine. Various attempts have been made to produce a detachable motor which can be fitted to an ordinary cycle. One of the latest is due to W. S. Simpson, and can, with but little alteration, be added to existing bicycles. The motor and its equipment are carried on a frame on tubular shafts, which extend from the axle of the rear wheel backwards, looping round the wheel, with a second loop extending towards the ground; this latter carries the engine, which is also supported by a castor wheel at the rear. As the motor possesses a certain amount of vertical "play," it rides easily behind the machine, which it propels by a chain. Extra large petrol tanks (capacity for 100 miles) are carried on the shafts. Control from the handle bar is effected by Bowden wire connections, and any type of motor may be used. The machine answers capitally, and is of particular value to ladies, as there is no extra machinery, oil, heat, or complication to interfere with the dress. Vibration is almost annulled, and the motor can be readily detached when required. ADDITIONAL ATTACHMENTS TO MOTOR CYCLES: The average motor cycle is strong enough to carry an extra load or passenger. There are three principal forms of attachment: (1) TRAILER: A small two wheeled "bath chair" wicker seat trailed behind the motor; it is practically extinct. (2) SIDECAR, with one wheel, the other side being attached to the motor cycle frame; it brings the passenger alongside the driver, and is much the most companionable form. (3) FORECAR: The front wheel of the bicycle is removed, and the steering pillar fits on behind the axle of a light two wheeled chair seat, which is secured by side tubes, etc., to the bicycle. It gives a seat immediately in front of the driver, and is the

most popular and effective form of passenger device. OTHER FORMS OF MOTOR CYCLE OR CYCLE CARS: Correctly speaking, a cycle is "a wheeled vehicle propelled by the action of the feet," and the motor merely an addition thereto; but the tendency is to make motor "cycles" without pedals, more particularly tricycles and quads (four wheelers). Many of these are built with permanent seats for a passenger. The arrangements of the motor tricycle and quadricycle differ from the bicycle chiefly in the following points: (1) The engine is fixed close to the back axle, to which the power is transmitted from the crank shaft by a train of gear wheels. (2) The cylinder is usually "water cooled" (*q.v.*) These arrangements introduce extra complications, which cause a well made motor cycle with three or four wheels to be almost as elaborate in its mechanism, and therefore nearly as expensive, as a small light car. On this account the distinction between the car and the motor cycle now tends to become more marked than ever. The tricycle and quadricycle are disappearing, having been displaced by the TRICAR. This type, a direct development of the motor bicycle (as distinguished from the motor tricycle), is coming more and more into favour. The best known, and practically the originator of the type, is the Trimo. It retains, however, the motor bicycle type as a basis (pedals being retained), and to this form (or that of a tricycle) it can be restored with a little alteration. In the more elaborate patterns the body is hung on C carriage springs. A free engine is fitted with two speeds and a clutch, which can be slipped after the rider and passenger are mounted, thereby starting the machine.—H. H. G.

Motor Dynamo (*Elect. Eng.*) An electric motor combined with a dynamo. The former is actuated by an electric current and drives the dynamo, which produces a second current differing from the first in voltage, etc. An alternating current may be changed to a direct current, or *vice versâ*, or a high voltage continuous current transformed to a low voltage one by this means.

Motor—Oil, Petrol, Spirit (*Eng.*) *See* PETROL ENGINE, *etc.*

Motors, Electric. The direct or alternating current dynamo can, instead of converting mechanical into electrical energy, perform the reverse process without any change in its mechanical construction or electrical connections. It is then termed an ELECTROMOTOR. Rotatory motion due to electromagnetic action was first produced by Faraday in 1831, closely followed by Salvatore del Negro and Pixii. Other pioneers in direct current motor development were Jacobi, Pacinotti, Gramme, and Siemens. In 1873 the first public electric power transmission scheme was shown at the Vienna Exhibition, when two similar Gramme machines were used—one as the generator, the other as the motor, the distance between the two being a bare third of a mile. The first alternating current polyphase motor was made by Bailey in 1879, Deprez and Ferraris almost simultaneously following up this method of power conversion. Whenever two sets of lines of force (*q.v.*) or separately generated magnetic fields occupy a common zone, a tendency exists for the lines to so alter their paths that as many lines as possible shall coincide in direction, each field being therefore distorted from its natural arrangement. This mutual distortion sets up a recovering stress which is imparted to the magnet or current carrying coil producing the field, the effect of which is a tendency to motion in the material substance employed. When one or both of the fields are due to a current flowing in a conductor, the tendency to motion of each wire is at right angles to the direction of the field acting on it, and also to the direction of flow of current in it. A coil (fig. 1), pivoted on axis XY, having a

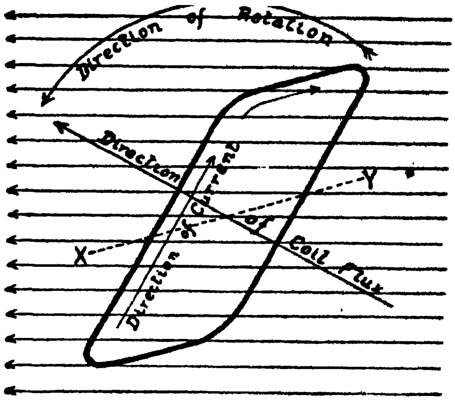


FIG. 1.

current flowing round it in the direction shown, and placed in a magnetic field shown by the long straight arrows, will rotate in the direction of the large curved arrow until the lines of force developed by the current in the coil coincide with the direction of the field. If the current direction were reversed, the coil, if moved out of its position of equilibrium, would tend to move through a semicircle to a fresh position of rest. A direct current motor essentially consists of a collection of such coils arranged cylindrically and provided with a current reverser or COMMUTATOR, the brushes being so placed that all the current carrying coils assist each other in producing continuous rotatory motion. During such motion the conductors cut the lines of force of the field, producing a counter electromotive force, and constancy of rotation is obtained when this back electromotive force, plus the volts lost in armature resistance, equal the voltage of supply to the armature. The commercial efficiency of a motor is the ratio of the mechanical output ($= 2\pi n\text{T}$ foot pounds per minute, where n = revolutions per minute, T = TORQUE (*q.v.*) or twist on the armature in pound feet) to the electrical in-put ($= \frac{\text{CV}}{746}$, where C = current supplied to the motor, V = voltage of supply). This ratio is usually expressed as a percentage. The full load efficiency of direct or alternating current motors varies from 95 to 70 per cent., according to size, speed, and condition of working. The losses are due to friction of bearings, and, in some types, of brushes; air friction or "windage"; magnetic hysteresis (*q.v.*) in the iron parts; local eddy or Foucault currents (*q.v.*) in the conductors, and heat losses on the conductors. The torque is equal to the product of the average thrust in pounds on the armature conductors and the radius of these conductors in feet from the centre of the shaft. Modern continuous current motors, precisely like continuous current dynamos, have revolving armatures and fixed fields. The field may be in series or shunt to the armature, and compound or

differentially wound motors are sometimes, though not often, used where great constancy of speed is desired. *See* DYNAMOS. Where a high starting torque is required (*e.g.* in traction work) a series motor is employed. On tramway systems the modern motor is a four pole series motor wound for 500 volt circuits and thoroughly waterproofed. A series motor will not run at constant speed with varying load, and must be continually regulated by a "controller" or hand operated switch resistance. A shunt motor, if of small armature resistance and strong field, will give an almost constant speed with varying loads, and hence needs little manual control beyond starting and stopping. In starting a series or shunt motor a STEPPED RESISTANCE (*q.v.*) must be placed in series with the armature to avoid an excessive rush of current. Reference is made in the article on dynamos to the necessity of giving a forward lead to the brushes. In a motor the lead is backward, as the armature current flows in an opposite direction with respect to the field to that in a dynamo. Modern practice is in favour of using multipolar in preference to bipolar machines, except for very small outputs. Two alternators cannot be run as generators in series unless mechanically coupled, for if they become ever so slightly out of phase the resulting current retards the lagging machine by throwing work into it, and accelerates the leading one, until they fall into complete opposition of phase, one driving the other; hence one becomes a generator, the other a motor. There is no difference in the construction of a synchronous alternating current generator and motor, these being reversible simply by the conditions of loading. This applies alike to polyphase and single phase alternators. The description of these alternators (*see* DYNAMO) therefore applies to such motors. In order to connect this type of motor to an alternating current supply it must be "synchronised," *i.e.* it must not be switched on to the mains until its frequency, terminal voltage, and phase are identical with that of the supply. A separate direct current supply is necessary to excite the field magnets of the alternator unless a special commutating device is mounted on the shaft, whereby a portion of the current thus rectified can be shunted through the field, as in the case of a rotary converter. Let a ring of soft iron be continuously wound with a coil (fig. 2), having four tappings (or points at which it is connected to external conductors), and two independent alternating currents, of the same frequency, but differing in phase by a quarter period, be led into the winding by tappings AB and CD respectively. When circuit AB has its maximum current, that in CD will be *nil*. At this instant a zone of magnetism is set up of general direction CD. A quarter period later a zone is set up of direction AB. Between these times one zone dies out as the current diminishes, the other zone increasing. These combine to form a resultant zone shifting in direction from CD to AB. This continues throughout the period, and we get a rotating field due to the stationary or STATOR windings. If, now, a bundle of short circuited conductors be placed within this ring, currents are induced due to the cutting of conductors by the lines of force. These currents in their turn set up magnetic fields. If the currents lag behind the impressed electromotive forces due to the cutting, the induced fields lag behind the inducing field. There will be a constant effort of the induced field to align itself with the inducing field, which effort is transmitted to the substance of the conductors, and rotation ensues. This is the principle of the POLYPHASE INDUCTION MOTOR, and can be applied to any number of phases. In large commercial machines the revolving (or rotor) windings are usually grouped systematically, and have facilities for connection to external resistances for use in starting. The same principle may be applied to single phase currents by placing circuits AB, CD, in parallel on the supply mains, but feeding, say, AB through a non-inductive resistance and CD through a highly inductive coil. The phase CD is thereby retarded behind that of AB, and a rotating field produced. Full speed having been obtained, this starting device or PHASE SPLITTER may be cut out of action, the machine continuing running by its internal reactions. To increase the effect the rotor conductors are embedded in iron. In order to ensure efficiency, the iron employed both in stator and rotor must be of the softest description and well laminated, and the gap between the fixed and rotating parts must be as small as practicable. The efficiency of these machines is not so high as that of synchronous motors of the same output, as, owing to the high inductance of the iron circuits, heavy lagging currents occur, causing much heat waste. A recent type of alternate current motor is the repulsion motor, which is similar in construction to a direct current motor, with the exception that the field is made of laminated iron having an alternating current passed through it from the mains. The brushes, which are placed at an angle from their neutral position, are short circuited. The closed circuit thus formed produces a magnetic flux at an angle to the main flux of the field. By the effort of this flux to align itself with that of the field, the conductors under the brush are dragged round, and as fresh conductors continually come into position the rotation is continuous. When the motor is up to speed the brushes may be lifted, the motor then running as a single phase induction machine. The same effect is produced by "shading" part of the (laminated) polar projections of an alternating current electromagnet by sheets of copper, producing a lag of phase in this portion of the field due to the eddy currents, and so producing a shifting zone of magnetisation. An ordinary induction machine rotor is used.—J. A. S.

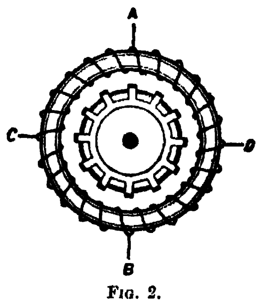


FIG. 2.

Motor Spirit. *See* PETROL, *etc.*

Mottled Soaps. A domestic soap, mostly of a common grade, which possesses a mottled appearance not unlike marble, such as white with blue veins or grey with darker grey veins. Mottled soaps are now not much used in England, but large quantities are exported to the Colonies and elsewhere.

Motto (*Her.*) A pithy sentence or even a single word appended to an escutcheon. Sometimes it is a punning device; *e.g.* the motto of the Vernon Harcourts is *Ver non semper viret.*

Mould. The matrix in which an object is cast, and from which it receives its form. *See* CAST; LOST WAX PROCESS.

Mould (*Carp. and Join.*) A thin piece of wood or zinc cut to shape (profile), serving as a template (*q.v.*) or guide in cutting scrolls, handrails, or other curved work.

—— (*Foundry*). The hollow space into which liquid metal is poured in order to produce a casting. Moulds are made of sand and loam for iron, steel, or brass castings; but they may be of some metal when castings are required in lead, pewter, or similar fusible alloys.

—— (*Paper Manufac.*) A wire cloth fixed to a wooden frame, used for making paper by hand.

—— (*Plast.*) A template or piece of zinc cut out the reverse of the profile of a moulding to be run in plaster.

Moulders (*Foundry*). The workmen in the foundry who make the moulds, cores, etc., by means of the patterns and core boxes supplied by the pattern makers.

Mould, Formation of (*Geol.*) This is due almost entirely to the combined effects arising from the action of various chemical, organic, and physical changes affecting rocks at a short distance below the surface of the land. One of the most potent causes of change is that set up by bacteria, which convert dead vegetable matter into the humus acids, solutions of which, in their turn, dissolve many of the rock constituents, and thus help to convert the residue to a pliable state capable of easy transport by the wind. Worms may perform a share of the work.

Moulding (*Architect., etc.*) A generic term applied to the various contours or sectional outlines of such features as string courses, cornices, plinths, bases, capitals, door and window jambs, arches, etc. *See* ASTRAGAL, BEAD, TORUS, FILLET, CYMA, CAVETTO, OVOLO, SCOTIA, BOWTELL, ROLL MOULDING, *and* SCROLL MOULDING.

—— (*Foundry*). The formation of MOULDS (*q.v.*) This operation is carried on either by the use of patterns (*q.v.*) or in certain cases by shaping or striking the mould in loam by means of LOAM BOARDS (*q.v.*)

Moulding Box. The iron frame holding the sand in which moulds are formed; often termed a FLASK.

Moulding Cutter (*Carp.*) A revolving cutter, whose profile is formed into a shape the reverse of a moulding which has to be cut. It is attached to a spindle rotated at a high speed by power.

Moulding Letters. Metal letters used for producing the mould for casting letters on name plates, etc., instead of actually cutting the letters on the pattern.

Moulding Machine (*Foundry*). Mechanism used for producing comparatively simple moulds, of which a number are required all alike. Moulds for cast wheels are conveniently made by means of moulding machines, and a complete pattern is not required.

Mound (*Her.*) *See* MONDE.

Mount (*Her.*) A tump or hillock at the base of a shield, generally vert.

Mountain Chains. A geographical term that is often applied to any group of mountains which happen to occur more or less in line with each other, whether they are due to terrestrial uplifts formed under the same conditions or not. Most typical mountain chains are, like the Andes, great surface wrinkles, primarily due to movements of the Earth's crust, and are correlative to adjacent zones of depression.

Mountain Cork (*Min.*) A loose porous variety of Amphibole (*q.v.*) It is often so light as to float on water; it occurs in fissures in rocks which have had some of their ferromagnesian silicates decomposed.

Mountain Meal. A synonym for Kieselguhr. *See* DIATOM.

Mountain Railways (*Civil Eng.*) A term properly restricted to lines on which the adhesion of the locomotive wheels to the rails is insufficient to propel the train, necessitating the use of other means. These other means are usually a CABLE (*q.v.*), some form of RACK, or a central rail gripped by horizontal wheels on the locomotive, as in the FELL RAILWAY (Mont Cenis, etc.) The rack systems include the LADDER RACK, formed of bars (Mount Washington, U.S.A.); LOCKER RACK (Pilatus), in which the teeth are on two sides of a central rail and the toothed wheels gearing with them are horizontal; FLAT BAR RACK (St. Eilero, Italy); and ABT RACK, with two (or three) flat racks side by side, their teeth being arranged stepwise, so as not to come in line with each other (Hartz Mountain Railway). The Abt Rack appears to be the most satisfactory of all these systems. *See also* RAILWAYS.

Mountings (*Eng.*) A general term for the small parts that are added to a machine, etc., when the main parts are complete; especially the fittings added to a boiler after the shell leaves the hands of the boilermakers.

Mount Sorel Granite. *See* BUILDING STONES.

Mounture (*Silk Manufac.*) A figured harness composed of cotton or linen thread, built up to and connected with the Jacquard machine in such a way as to operate on the warp threads either singly or by sections.

Mouse Mill (*Elect.*) A simple form of electrical induction machine; used in charging the needle of a quadrant electrometer.

Mouse Roller (*Print.*) A small roller connected with the inking arrangements of printing machines of the Minerva pattern; used for distributing the ink evenly on the disc.

Mouthpiece (*Music*). That part of wind instruments which is applied to the lips. There are three kinds: (1) reed, as in the clarionet or bassoon; (2) cupped, as in the trumpet; (3) a hole, as in the flute. *See* MUSICAL INSTRUMENTS (WIND).

Movable (*Typog.*) A term applied to type in order to distinguish it from stereotype, electrotype, etc.

Movable Bridges (*Civil Eng.*) These embrace FLOATING, SWING, TRAVERSING, LIFT, and BASCULE BRIDGES (*q.v.*)

Movable Do (*Music*). A term applied to the Tonic Sol-Fa system, in which the keynote is always called Do. The movable Do is the essential characteristic of the modern or Tonic Sol-Fa system, as distinguished from the older system, in which the term Do is applied only to the note C (Fixed Do). *See also* TONIC SOL-FA.

Movable Weirs (*Civil Eng.*) Weirs which can be adjusted in height or entirely removed during floods, etc. They include FRAME, SHUTTER, and DRUM WEIRS (*q.v.*)

Movement (*Music*). A section of a larger work, such as a sonata. Each section or movement is complete in itself as to form, although each movement should have a connection with the whole work.

MS. An abbreviation of the word "manuscript." MS. is generally termed "copy" (*q.v.*) by printers.

M.S. (*Music*). The left hand; the letters standing for the Italian *Man Sinistra*. The equivalent in English is L.H., and in French M.G (*Main Gauche*).

MSS. An abbreviation of the word "manuscripts."

Mucic Acid (*Chem.*), COOH . CHOH . CHOH . CHOH . CHOH . COOH. Small white rhombic prisms; melts with decomposition at 210°: sparingly soluble in cold water; more soluble in hot water; insoluble in alcohol. Prolonged boiling with water converts it into a soluble lactone (*q.v.*) (paramucic acid). Heated with pyridine it is converted into a stereoisomeric acid (allomucic acid). Heated with a mixture of concentrated hydrochloric and hydrobromic acids it yields α, α'-furfurane dicarboxylic acid,

$$\begin{array}{l} CHOH \,.\, CHOH \,.\, COOH \\ | \\ CHOH \,.\, CHOH \,.\, COOH \end{array} = \begin{array}{l} CH = C \,.\, COOH \\ | \qquad\quad \rangle O \\ CH = C \,.\, COOH \end{array} + 3H_2O$$

which loses CO_2 on heating, forming pyromucic acid, $\begin{array}{l} CH = C \,.\, COOH \\ | \qquad \rangle O \\ CH = CH \end{array}$. Ammonium mucate on heating yields pyrrol, $\begin{array}{l} CH = CH \\ | \qquad \rangle NH \\ CH = CH \end{array}$. Heated with barium sulphide, mucic acid yields α-thiophene carboxylic acid, $\begin{array}{l} CH = C.COOH \\ | \qquad \rangle S \\ CH = CH \end{array}$.

The acid is obtained by oxidation of many kinds of gum, and by oxidation of dulcite, galactose, and lactose. The formula shows the acid to contain four asymmetric carbon atoms; it should exist therefore in ten stereoisomeric forms. Ordinary mucic acid and allomucic acid have the configurations

$$\begin{array}{c} COOH \\ | \\ HO-C-H \\ | \\ HO-C-H \\ | \\ HO-C-H \\ | \\ HO-C-H \\ | \\ COOH \\ \text{Allomucic Acid.} \end{array} \qquad \begin{array}{c} COOH \\ | \\ H-C-OH \\ | \\ HO-C-H \\ | \\ HO-C-H \\ | \\ H-C-OH \\ | \\ COOH \\ \text{Mucic Acid.} \end{array}$$

(Both these are inactive.)

Mudar (*Botany*). An Indian tree, *Calotropis gigantea* (order, *Asclepiadaceæ*), whose bast fibres form good material for cordage. The down on the seeds is used for stuffing cushions.

Mud Box (*Eng.*) A cavity provided in pumps, etc., to serve as a mud trap, *i.e.* to stop mud and grit from entering the valves.

Mud Bucket (*Eng.*) The bucket of a dredger, *i.e.* the part which actually scoops up the mud.

Mud Guards (*Cycles*). Made of thin iron, steel, leather, or celluloid. They should prevent mud from reaching the running parts of the machine, as well as keep it from the rider.

Mud Hole (*Eng.*) A door or hole near the bottom of a boiler or tank by means of which mud and sediment can be removed.

Mud Hole Door (*Eng.*) An elliptical plate, fitting a seating or mud hole of the same form, in boilers, etc. It is passed through the opening, then pulled up against its seating, and held fast by a bolt fixed to an arch which spans the hole outside the boiler; the internal pressure tends still further to keep it tightly closed.

Muds (*Geol.*) Clays or other argillaceous matters rendered semifluid by admixture with water. In addition to the muds of the land, rivers, and lakes, there are extensive submarine deposits which cover the ocean floor for many thousands of square miles. Most of these are of terrigenous origin. They are usually classed as (1) shallow water muds, which have been deposited in depths less than 100 fathoms; and (2) deep sea muds, which have been left at greater depths. These include blue, red, and green muds; also volcanic mud, and the calcareous mud derived from coral reefs.

Muffle Furnace (*Met., Assaying, etc.*) A furnace resembling an oven, in which cupels (*q.v.*) or small crucibles can be placed to be heated without direct contact with the flames or fuel. The actual oven, or MUFFLE, is an arch shaped vessel of fireclay.

Muffler (*Motor Cars*). A SILENCER (*q.v.*)

Mulberry. *See* WOODS.

Mule (*Cotton Spinning*). An intermittent spinning machine very suitable for medium and fine counts, soft spun yarns, and elastic yarns. It consists of three main parts: (1) the headstock; (2) draw rollers and beams; (3) carriage, which holds from 800 to 1,500 spindles placed side by side. The rovings are finally drawn out and twisted to the required fineness to form the spun thread of commerce. The drawing and twisting are done simultaneously, but the winding of the spun threads on to the spindles is performed separately, as the carriage recedes inwards. All sources of motion for the numerous operations necessary are obtained from the headstock. Mules are specially constructed for spinning (*a*) twist or (*b*) weft in coarse, medium, or fine counts. Some are capable of spinning as high as 350 counts.

Muller (*Paint.*) A flat bottomed pestle for grinding painters' colours; now seldom used.

Mullet (*Her.*) A charge formed like a star. It has generally five points, and is sometimes represented pierced or voided. The rays are always straight, thus differing from estoile, which has wavy

rays. If of more than five points, the number must be given; this is then generally called a star. When used as a mark of cadency it denotes the third son.

Mullion (*Architect.*) A vertical bar separating the lights in a Gothic window or screen. It is also known as a Monial or Munnion.

—— (*Join., etc.*) The vertical member, of larger section than a bar, that divides a window into lights.

Multicellular Voltmeter (*Elect.*) *See* VOLTMETERS.

Multifoil (*Architect.*) A cusped opening in Gothic tracery formed with a large number of foils, or spaces between cusps. *See* FOIL, CUSP, CINQUEFOIL, *and* QUATREFOIL.

Multiphase (*Elect. Eng.*) *See* POLYPHASE.

Multiple Arc *or* **Circuit** (*Elect.*) A number of conductors arranged in PARALLEL (*q.v.*)

Multiple Boiler (*Eng.*) A boiler with a number of tubes, *i.e.* a tubular boiler.

Multiple Drilling Machine (*Eng.*) A machine with a number of parallel drilling spindles; used for such work as the simultaneous drilling of a number of holes along an iron girder, boiler plate, etc.

Multiple Star (*Astron.*) A star which has one or more companions physically connected with it.

Multiple Telegraphy (*Elect. Eng.*) The simultaneous transmission of two (or more) messages along a single wire. *See also* TELEGRAPHY.

Multiple Threaded Screw (*Eng.*) A screw with two or more distinct threads or helices.

Multiplex Telegraphy (*Elect. Eng.*) *See* MULTIPLE TELEGRAPHY.

Multiplying Power of a Shunt (*Elect.*) *See* SHUNT.

Mundic (*Min.*) A synonym for PYRITES (*q.v.*)

Munnion (*Architect.*) *See* MULLION.

Munt *or* **Munting** (*Carp. and Join.*) A vertical member dividing the panels between the outside styles, *e.g.* the central vertical part of an ordinary panelled door.

Muntz Metal (*Eng.*) A kind of brass (3 parts copper to 2 parts zinc) used for the tubes of surface condensers and locomotive boilers, also for sheathing wooden ships.

Mural Crown (*Her.*) The crown is represented as made of squared stone, and is embattled.

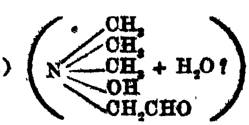
Mural Decoration. *See* PAINTING (METHODS), CUIR BOUILLI, HOUSE PAINTING, PANELLING, WALL PAPERS, WAINSCOT, TAPESTRY.

Murex (*Art*). A twisted shell portrayed as a horn: a conch. Generally an attribute of tritons, etc.

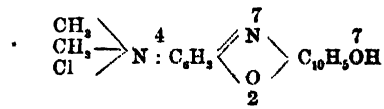
Murexide (*Chem.*) *See* URIC ACID.

Muriatic Acid (*Chem.*) A common name for hydrochloric acid (*q.v.*)

Murrey *or* **Sanguine** (*Her.*) A tincture used in ancient heraldry: a dark brown.

Muscarine (*Chem.*) 

A colourless, strongly alkaline, difficultly crystallisable syrup; very soluble in water and in alcohol; very poisonous. Forms salts with acids, and its salts give precipitates with the alkaloid reagents (*q.v.*) except iodine in potassium iodide. It occurs in putrid fish and in the poisonous fungus called fly agaric; but it is doubtful if all the poisonous action of this fungus is due to muscarine. Muscarine has been obtained artificially by the oxidation of choline (*q.v.*) by nitric acid. The same name, muscarine, has also been applied to a totally different substance—a blue dye.



Muschetors *or* **Mushetours** (*Her.*) The black tail of ermine without the three dots or spots above.

Muscle Sugar (*Chem.*) *See* INOSITE.

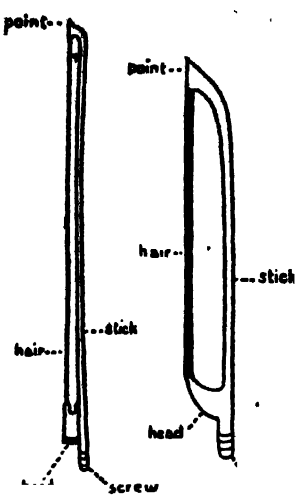
Muscovite (*Min. and Geol.*) A hydrous potassium and aluminium orthosilicate; composition rather variable, typically $2H_2O . K_2O . 3Al_2O_3 . 6SiO_2$. Monosymmetric. Usually in tabular pseudo-hexagonal crystals with a perfect basal cleavage. One of the Mica group (*q.v.*) Of wide distribution in eruptive and metamorphic rocks. It is of considerable commercial importance when in large plates, such as are obtained in the United States, Siberia, etc. It is an important constituent of most rocks that have been affected by dynamic metamorphism, this mineral being due to conversion from fragments of potash felspar. It occurs, for the same reason, in many gneisses and their related pegmatites. As an original constituent of eruptive rocks it is somewhat rare. Being, like quartz, a mineral that is decomposed by natural causes only with great difficulty, scales of Muscovite survive most of the changes that affect other minerals, and it therefore occurs, as a derivative mineral, quite commonly in most sandstones and allied rocks.

Musical Box (*Music*). A cylinder, with pins protruding, which is made to revolve by a kind of clockwork spring. In so doing the pins come into contact with certain teeth on a steel comb, tuned to the scale. The musical box is about a hundred years old, and is chiefly made in Switzerland.

Musical Instrument. A sonorous body by means of which musical sounds are produced.

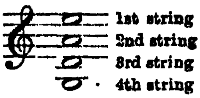
Musical Instruments. These may be divided into three classes, *viz.* (1) Stringed instruments; (2) Wind instruments; (3) Instruments of percussion. (1) STRINGED INSTRUMENTS are of three kinds: (A) Played by a bow. This class comprise the violin, viola, violoncello, and double bass. The bow consists of a stick, tapering towards the point, that has been formed by being regularly bent whilst it was subjected to a certain heat for a considerable time. Horsehair is attached to the point and head, and by means of a screw the hairs can be tightened or loosened. Resin is applied to the hairs to increase the friction on the strings of the instruments. The present bows were invented by Tourte, a Frenchman,

towards the end of the eighteenth century. The length of the bows are: violin and viola, 29 in. (about); violoncello, 28½ in. (about); double bass, 26 in. (about). (B) Played by the hand, comprising the mandoline, guitar, banjo, zither, and harp. (C) Played by percussion, comprising the pianoforte, dulcimer, and cymbals.



VIOLIN BOW. DOUBLE BASS BOW.

(A) The VIOLIN (fiddle) has four strings tuned in perfect fifths, thus:



These are called the open notes, and in fingering are

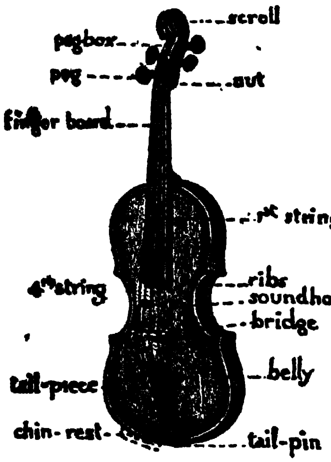


FIG. 1.—VIOLIN AND PARTS.

marked by a small o placed above the notes. It has a chromatic compass from

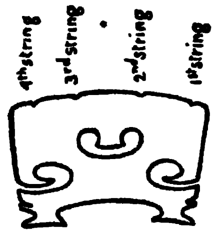
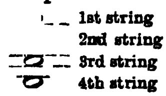


FIG. 2.—BRIDGE.

Chords of two, three, or four notes are possible if judiciously written. The illustrations (figs. 1 and 2) show the different parts of the violin and the bridge on which the strings rest. In orchestral music the violins are generally divided into two parts—firsts and seconds. The violin is the leading instrument in the orchestra, and the principal first violinist is called the leader of the orchestra. Two of the most celebrated makers of violins were Stradivarius (a pupil of Nicholas Amati) and Joseph Guarnerius, both of whom lived in the latter half of the seventeenth and the beginning of the eighteenth centuries. *See* CREMONA.

The VIOLA *or* TENOR has four strings, tuned in perfect fifths, thus:



and has a chromatic compass from

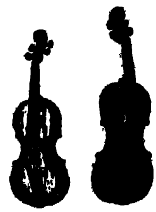
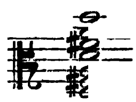
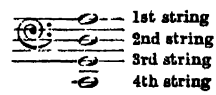


FIG. 3. VIOLIN. FIG. 4. VIOLA.
To Scale with Violoncello and Double Bass.

As on the violin, chords of two, three, or four notes are practicable. Music for this instrument, excepting the highest notes, is written in the alto stave (with the C clef on the third line). The tone of the viola is somewhat nasal, and the lower notes are especially adapted to melodies of an emotional character. The *viol da braccia* is the viol to be played supported "on the arm," and is virtually the present viola. The *viol da gamba* is the viol to be played supported "between the knees." It is now obsolete. There were two kinds—the six stringed and the seven stringed. The tone was lighter and of a more nasal character than the present violoncello. The *viol d'amore* is now nearly obsolete. It is about the size of the present viola, and has seven gut strings and seven sympathetic (resonance) strings, generally tuned as follows:



The VIOLONCELLO (CELLO) has four strings tuned in perfect fifths, thus:

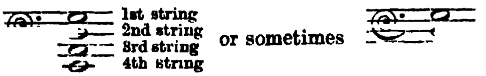


being an octave lower than the viola. It has a chromatic compass from

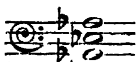
or even higher. Music for this instrument is written on the bass stave, excepting the higher notes, which are written on the tenor stave (with the C clef on the fourth line). Occasionally the treble stave is used, and unfortunately when this stave is used some composers have written the notes an octave higher than they are to be played, whilst others have written the actual notes. Modern composers use the treble stave only for the highest notes, and write the actual sounds. Chords of two, three, or even four notes can be played, provided they are judiciously written.

The DOUBLE BASS is of two kinds: the three stringed, tuned thus:

and the four stringed, tuned thus:



The lowest string is even tuned down to C♯ or C♮ at times. Double basses in military bands often tune to



in order to facilitate playing in flat keys, and in fact the exigency of the case regulates the tuning of this instrument. In all cases the compass extends to

with all the intermediate semitones from the lowest note according to the tuning. Music for the double bass is written on the bass stave, and the notes sounded are an octave lower than those written. Double notes are seldom written for this instrument, but passages of extreme rapidity can be performed with great effect. The actual compass of the different strings therefore is:

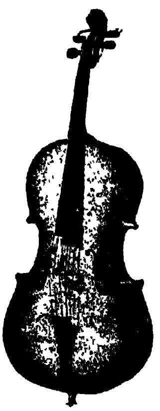
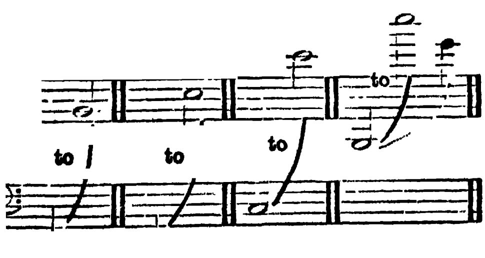


FIG. 5. VIOLONCELLO.


FIG. 6. THREE STRINGED DOUBLE BASS.

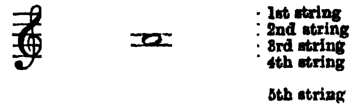
To Scale with Violin and Viola.



Double Bass. Violoncello. Viola. Violin.
(Sounding 8ve lower.)

As remarked above, the double bass lowest note varies. The note given as a crotchet is the ordinary orchestral upward compass of the second violin. *The illustrations of the violin, viola, cello, and double bass (figs. 3, 4, 5, 6) are to scale.*

(B) MANDOLINES are of two kinds: the Milanese and the Neapolitan, the latter being the more popular. The Milanese mandoline has five sets of double strings (that is, two strings tuned in unison to each note), thus:

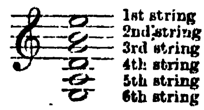


The Neapolitan mandoline has four sets of double strings, tuned to the same notes as the violin (*q.v.*), and has a chromatic compass from


NEAPOLITAN MANDOLINE.

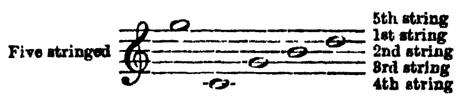
This instrument is played by plucking the strings with a "plectrum," generally made of tortoiseshell. In Sir George Grove's *Dictionary of Music and Musicians* there is printed a composition for this instrument by Beethoven, and Mozart uses it in his *Don Giovanni*. Chords of two, three, or four notes can be played on this instrument.

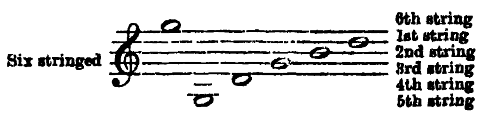
The GUITAR has six strings, tuned thus:

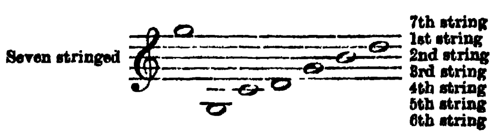


the notes sounding an octave lower than written. The tone of the guitar is of very sweet quality. It is played with the fingers, and from the way chords and arpeggios can be effectively performed it is specially suited for voice accompaniment. This instrument has a flat back.

The BANJO has five, six, or seven strings, tuned respectively as follows:

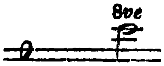




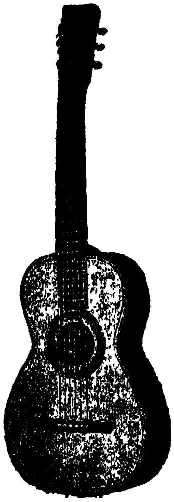


In America the tuning is a minor third lower. The

five stringed is by far the most popular. Its compass is from



including all the semitones, sounding an octave lower than the notes written. It is played either by plucking the strings like a guitar, or by striking them with the back of the nails. The highest string (fifth, sixth, or seventh) is called the melody string, and is sometimes played by striking it with a "pick" made of ivory instead of the back of the thumbnail. Chords can easily be played on this instrument.



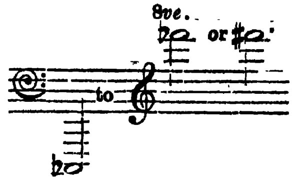
GUITAR.

FIVE STRINGED BANJO.

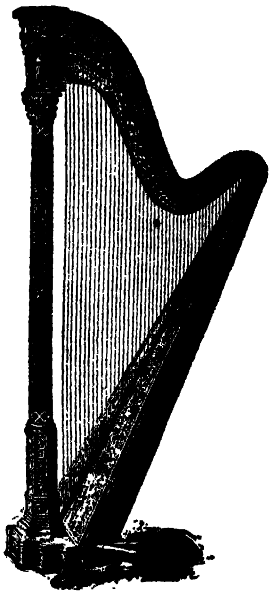
ZITHER.

The ZITHER consists of a sounding box strung with gut, silver wire, and copper strings. Five of these are on a finger board tuned like the viola, excepting that the first and second strings are tuned in unison to A. The remaining strings are called accompaniment strings, and vary in number. It is played with the fingers of the right hand and with both thumbs; the right hand thumb wears a silver ring, with which the five melody strings are struck.

The HARP is by far the most important of stringed instruments played by the hand. It has a compass from



The harp is tuned in the key of C♭, and has seven pedals, which raise their respective strings—C♭, D♭, E♭, F♭, G♭, A♭, B♭—either a tone or a semitone, at the will of the performer. For this reason it is called the "double action" harp. This double action was the invention of M. Erard, and allows music to be performed in any key. Chromatic passages, unless in very slow time, are impossible. Chords of two, three, or four notes can easily be played, especially if not extending over an octave in either hand, both of which are used to pluck the strings.



ERARD HARP.

(C) The PIANOFORTE was introduced into England at the beginning of the second half of the eighteenth century by Zumpe. Its immediate predecessor was the HARPSICHORD, the strings of which were plucked by a "quill." This quill was set in motion by a wooden upright fixed to the key, called a "jack." The harpsichord was an improved SPINET or VIRGINAL. But the oldest of this family of keyed stringed instruments was the CLAVICHORD, which dates from the early part of the sixteenth century, and which was the favourite instrument played by J. S. Bach. The

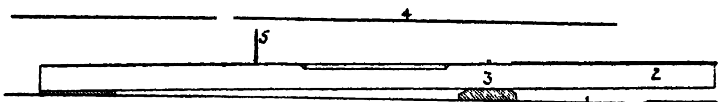


FIG. 1.—KEY ACTION OF CLAVICHORD.

1. Key bed. 2. Key. 3. Key fulcrum. 4. String. 5. Brass tangent.

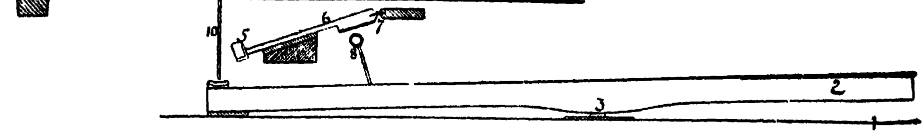
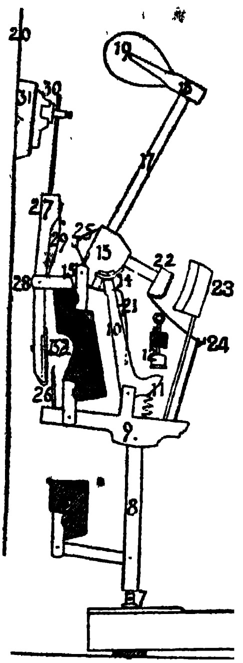


FIG. 2.—KEY ACTION OF ZUMPE'S PIANOFORTE.

1. Key bed.
2. Key.
3. Key fulcrum.
4. String.
5. Hammer.
6. Hammer shank.
7. Hammer hinge.
8. Sticker
9. Damper.
10. Damper lifter.

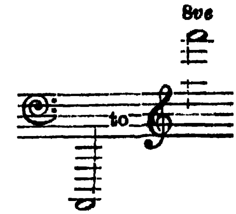


Explanation of Upright Action.

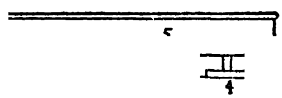
1. Key bed.
2. Balance rail.
3. Back baize.
4. Front pin and baize.
5. Key.
6. Balance mortice and pin.
7. Prolong regulating screw.
8. Prolong.
9. Under lever.
10. Sticker.
11. Sticker spring and set off arm.
12. Set off button and rail.
13. Hammer butt.
14. Notch.
15. Hammer centre.
16. Hammer beam.
17. Hammer shank.
18. Hammer head.
19. Hammer felt.
20. String.
21. Repetition spring.
22. Check button.
23. Check.
24. Tape tie.
25. Balance spring.
26. Damper lifter.
27. Damper stick.
28. Damper centre.
29. Damper spring.
30. Damper head.
31. Damper felt.
32. Damper lifting bar

Fig. 3.—Key Action of a Broadwood Upright.

pianoforte has gone through many changes in shape since its introduction. First it was oblong; then square; then came a "grand," which was of the shape of the harpsichord; then the upright, invented by John Isaac Hawkins in 1800, in which the strings extended above and below the keys; then came the "cabinet," followed by the "cottage" piano, bringing us to the two at present in use, the "upright" and "grand." Space will not allow of going into the many inventions of such famous makers as Messrs. Backers, Stodart, Sebastian Erard, Bluthner, Pleyel, Collard, Hopkinson, Brinsmead, Steinway, Bechstein, and John Broadwood & Sons. The last named firm have been the most intimately associated with the development of this instrument in England since 1732. Fig. 1, is a reproduction of the action of the clavichord; fig. 2, the action of Zumpe's pianoforte, made in 1766; figs. 3 and 4, the present (1904) action of one of Messrs. Broadwood's upright and grand pianofortes. The modern pianoforte has a chromatic compass from



The lowest eight notes (about) have one string only to each note; the next two octaves (about) have two strings, tuned in unison to each note; and the remainder of the notes have three strings each, tuned in unison; for this reason it is known as the "trichord" pianoforte. The strings are of steel wire, strung at very great tension (the total strain is from sixteen to thirty-two tons in a modern pianoforte), and are struck by hammers covered with felt worked from the keys. To each string, or set of strings, a damper of felt is added, which rests, when the key is released, against the strings, thus "damping" them and



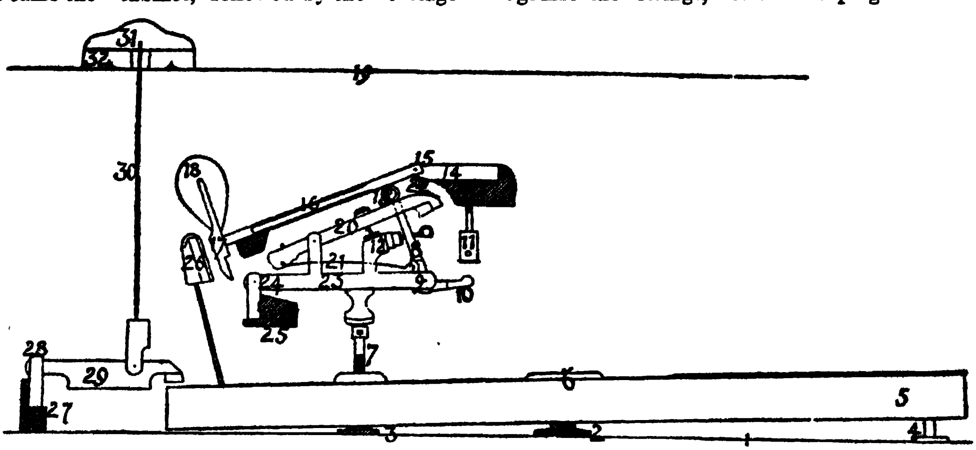
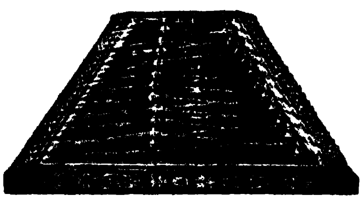


Fig. 4.—Key Action of a Broadwood Grand.

Explanation of Grand Action.

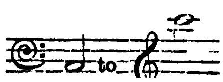
1. Key bed.
2. Balance rail.
3. Back baize.
4. Front pin and baize.
5. Key.
6. Balance pin and mortice.
7. Pilot screw.
8. Sticker.
9. Sticker centre.
10. Set off arm.
11. Set off button.
12. Sticker rest button.
13. Notch cushion.
14. Hammer fork.
15. Hammer centre.
16. Hammer shank.
17. Hammer head.
18. Hammer felt.
19. String.
20. Repetition lever arm.
21. Repetition set off spring.
22. Drop screw.
23. Carriage.
24. Carriage centre.
25. Carriage rail.
26. Check.
27. Damper rail.
28. Damper centre.
29. Damper lifter.
30. Damper wire.
31. Damper head.
32. Damper felt.

preventing them from vibrating. When the dampers are above the point at which the hammers strike the strings, it is known as the over-damper action; when below the point at which the hammer strikes the strings, as the under-damper action: this last is somewhat more quick in its action. Pianofortes have two or three pedals; if only two, that on the right is the sustaining pedal (popularly but erroneously called the loud pedal), which when depressed by the foot causes the dampers to remain away from the strings, allowing the vibration of the strings to continue. Its use is denoted by the abbreviation "Ped.," and its release is denoted by an asterisk. [It may here be pointed out that although the passage to be played is marked pianissimo, "Ped." would still stand for the right (sustaining) pedal, and not the left.] The pedal on the left is indicated by the words *una corda*, which mean "one string." This is brought about by the pedal shifting the action so that the hammers strike only one string instead of the three, the result being a diminution and remarkable difference of tone in the sound power. In modern trichord pianofortes, however, this pedal only shifts the action so that the hammers strike two of the strings instead of the three. In some instruments, instead of the former action, a strip of felt is dropped between the hammers and the strings when the left pedal is depressed, giving a muffled tone to the sound; this is called a *celeste pedal*. A third action of this pedal shifts the hammers nearer the strings; but the same result can as easily be attained by playing with less force. The release of the left pedal is indicated by the words *tre corde*, "three strings." On those instruments which have three pedals, the middle one holds the dampers exactly as they are when put into use, *i.e.* allowing the vibration of those strings which have the dampers off to continue, whilst damping the remainder of the strings so long as the pedal is kept depressed.



DULCIMER.

The DULCIMER: A small instrument, in no part more than 3 ft., with a wooden frame, and strung with from two to five wires in unison to each note. Its compass is from about

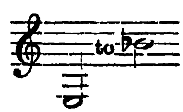


It is played by laying the instrument on a table or trestle and striking the wires with two hammers covered with leather, one in each hand. This instrument, being without dampers to stop the vibration of the wires, gives, especially in *forte* passages, a very confused combination of sounds.

The CIMBALO or CZYMBALO: A species of the dulcimer family, so called from its bell-like quality of tone. It has a compass of thirty-five notes. The lowest note has one string, the next fifteen notes have three strings each tuned in unison, and the remaining nineteen notes have four strings each tuned in unison. It is used a good deal by the Hungarian bands.

WIND INSTRUMENTS are of four kinds: (1) Those played by means of a reed mouthpiece, comprising the clarionets and saxophones (which have a single vibrating reed), and the oboe, oboe d'amore, cor Anglais or corno Inglese, the bassoon, the contra-bassoon (double bassoon), and bagpipes, each having a double vibrating reed. (2) Those played by means of a lateral mouthpiece, comprising the piccolo and flute. (3) Those played by means of a cup shaped mouthpiece, comprising the French horn, trumpet, trombone, cornet, flugel horn, tenor horn or saxhorn, baritone, euphonium, and bombardon (the last six comprise the "family" of SAXHORNS). (4) Those played by means of a keyboard, comprising the organ, harmonium, and concertina. The classification "wood" and "brass" has been avoided, firstly because instruments such as the flute, etc., though often made of wood, are also made of metal or ebonite; and, secondly, because the saxophone, although a brass instrument, is played by means of a reed, and so cannot strictly be classed in the same list as the trumpet, etc. In the first three classes of wind instruments the bore of some is cylindrical, that of others conical. With regard to the material used in instruments such as the flute, etc., it may be said that whilst it is more difficult to manufacture a "true" wooden instrument than one in metal, because of the liability of the wood to alter by warping, in performance the wooden one is more likely to remain true in pitch than the metal, owing to the effect produced by the heat of the breath. The variation is especially noticeable after a fairly long rest, unless the performer takes the precaution to keep the instrument warm. The SINGLE REED is made from a strip of cane, which beats or vibrates against the mouthpiece of the instrument. The DOUBLE REED consists of two strips of cane fastened together.

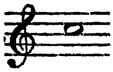
(1) The CLARIONET or CLARINET: An instrument of cylindrical bore ending in a bell, played by means of a single flat reed held by a double band to the mouthpiece. This instrument has a greater length in comparison to the size of the bore than any other of the conveniently termed "Wood wind" family (flute, oboe, clarionet, and bassoon), and this gives it a register of nineteen chromatic notes from



which is called "Chalumeau"; this is of a different quality from the other registers. By using the same fingering and opening the hole at the top of the instrument, a new series of sounds, a perfect twelfth higher, is obtained. In orchestral music three clarionets are in use, *viz.* in C, in B♭, and in A, but that in C is seldom used now, owing to its somewhat hard and unsympathetic tone. In military bands the clarionet in E♭ and others described below are in use. With the exception of the clarionet in C, all these are transposing instruments, *i.e.* the notes played are different from those written.

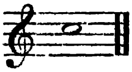
CLARIONET

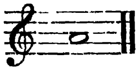
For instance, in a non-transposing instrument, like the clarionet in C, the note

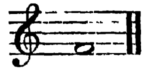


would sound exactly as written; whilst in transposing instruments, like the clarionet in A or the horn in F (*see* below), it would give the note by which the instrument is known, *e.g.*

Note written.	Note sounded by Clarionet in A.	Note sounded by Horn in F.



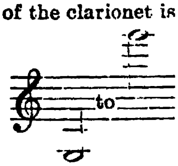




This necessitates the music being written in a key that allows for this transposition, and also prefixing a direction stating which instrument is to be used, as clarionet in A, or clarionet in E♭, etc. The transpositions of the clarionets are:

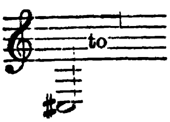
B♭	1 tone lower.
A	$1\frac{1}{2}$ tones lower.
E♭	$1\frac{1}{2}$ tones higher.

The full compass of the clarionet is from



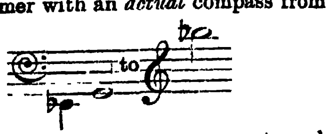
with all the semitones, the actual sound compass being as follows: Clarionet in C as given above; clarionet in B♭

Clarionet in A

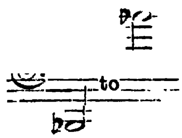


Clarionet in E♭

The instrument has from thirteen to fifteen keys. The choice of instruments obviates the need of writing in keys with many sharps or flats. Besides the foregoing instruments, there are tenor clarionets in E♭ and F, the former with an *actual* compass from



and the latter an *actual* compass one tone higher than the previous. Some makers add four lower keys to these tenor clarionets, carrying the compass down four more semitones to the note given as a crotchet in the compass of the tenor E♭. Both are transposing instruments, the E♭ a major sixth lower, and the F a perfect fifth lower than the written notes. This family is completed by the bass clarionet in B♭, which has a three-octave *actual* compass from



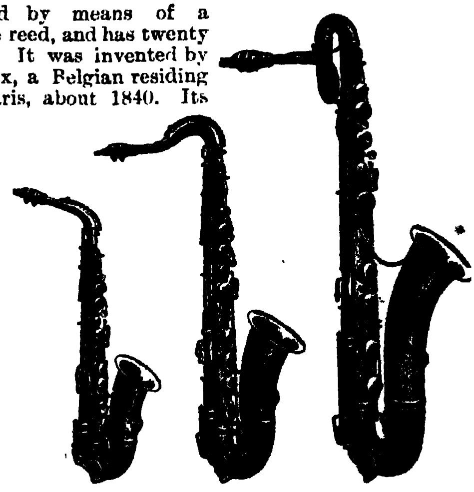
Music for this instrument is written either in the bass clef with the actual notes, or in the treble clef in the key of C; in the latter case it is a transposing instrument, sounding a major ninth lower than the notes written.

TENOR AND BASS CLARIONETS.

The BASSET HORN (*Corni di Bassetto*) is a similar instrument to the tenor clarionet in F, with the addition of four lower keys, and has a written compass from

It is a transposing instrument, sounding a perfect fifth lower, and possesses a fuller and finer tone than the clarionet.

The SAXOPHONE consists of a conical brass tube played by means of a single reed, and has twenty keys. It was invented by M. Sax, a Belgian residing in Paris, about 1840. Its



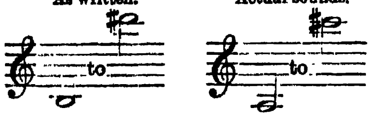
SAXOPHONES.

SOPRANO. ALTO. TENOR. BARITONE.

tone reproduces something of the 'cello quality, and gives sustaining power to the "full brass." It is used chiefly in military bands. We give illustrations of the four most frequently used saxophones, showing their relative sizes; but in addition there are the sopranino saxophone in E♭, an octave higher than the alto in E♭ (the alto is the favourite with saxophone soloists), and a bass saxophone in B♭, an octave lower than the tenor in B♭; they are, however, seldom used. The following table gives the compass of the instruments:

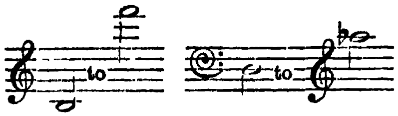
Soprano in B♭

As written. Actual sounds.



A tone lower.

Alto in E♭

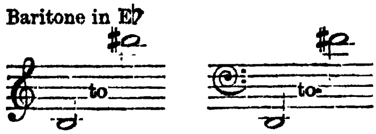


A major 6th lower.

Tenor in B♭

A major 9th lower.

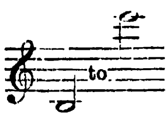
Baritone in E♭



A major 13th lower.

It will thus be seen that all are transposing instruments (*see* CLARIONET) and music is always written in the treble clef.

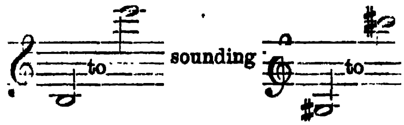
The OBOE: An instrument with a conical bore exceedingly small at the top. It has a delicate, refined, and plaintive tone, and is played by means of a double reed. It is an octave instrument, higher notes being obtained by octave keys. Its compass is from



or even a third higher with all the semitones. It has from fifteen to seventeen keys, and is a non-transposing instrument. The oboe is essentially a melodic instrument, and, owing to the difficulty in emitting the breath whilst playing, it is very necessary to give the player frequent rests. The best keys are those with not more than three sharps or flats in the signature. In the orchestra the performers tune their several instruments to the A given out by the oboe. Oboes are also made in B♭ and D♭, the former transposing a tone down and the latter a semitone up. The OBOE D'AMORE is a very similar instrument to the oboe. Its

OBOE.

quality of tone is more plaintive than the oboe, but in mechanism it is like that instrument. It is a transposing instrument (*see* CLARIONET), being in A, a minor third lower than the notes written. Its compass is from

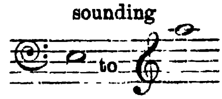


with all the semitones. Some very fine parts were written for this instrument by J. S. Bach, and latterly the instrument has been reconstructed and used at the performances of the Bach Choir in London.

COR

COR ANGLAIS (CORNO INGLESE) is to the oboe what the basset horn is to the clarionet (*q.v.*) It is a transposing instrument, being a fifth lower in the key of F. Its actual compass is from

sounding



The BASSOON (FAGOTTO) has, like the oboe (of which it is the bass), a double reed attached to a metal tube, called the crook, which is about 12 in. long. The crook is fitted in the instrument at (*a*) in the accompanying illustration, which shows the back and front of the bassoon. This instrument has a conical bore, and its internal length, with the crook, is a little over 8 ft. It has from seventeen to twenty-two keys. The instrument is supported by a strap placed around the performer's neck. It has a chromatic compass from

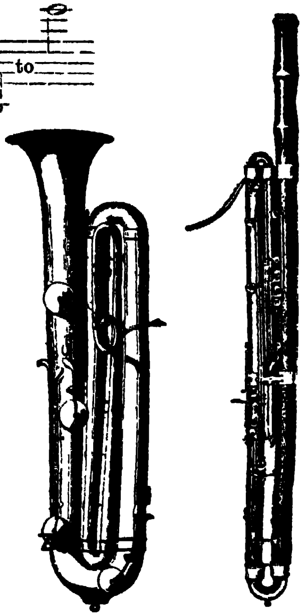
(three octaves), and is a non-transposing instrument; soloists even play good toned notes up to the F above. Music for the bassoon is written in the F (bass) and C clefs, the latter on the fourth line (tenor clef), and almost any kind of passage can be played effectively.

The CONTRA BASSOON (CONTRA FAGOTTO) or DOUBLE BASSOON is an octave lower in pitch than the bassoon, and it is curved four times for ease of handling. It is a little over 12 ft. in length internally, including the crook, and sounds an octave lower than the notes written, like the double bass. The fingering

BASSOON.

is similar to the bassoon and the compass is from

with all the semitones sounding an octave below. A new double bassoon has been introduced. It is made of brass, with a double reed resembling that of the bassoon, but somewhat larger, and is claimed to be much simpler in fingering and easier of performance. The tone is soft in quality, although of great power, and its compass is from

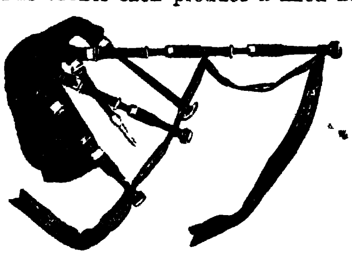


BRASS DOUBLE BASSOON. CONTRA BASSOON.

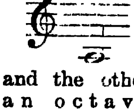
sounding an octave lower. Illustrations of both instruments are given.

THE HIGHLAND BAGPIPE consists of a leathern windbag which is filled by the performer through a valved tube, and three long tubes called drones and a smaller tube to which is fitted the chaunter. These four tubes are all inserted in the windbag, and the drones are thrown over the shoulder, while the chaunter tube is held in the performer's hand. The chaunter is fitted with a double reed, like the bassoon, whilst the three drones have single reeds of cane that in principle work very similarly to the organ reed. The chaunter is conical in shape, with seven finger holes in front and one behind, having a compass of nine notes from

The drones each produce a fixed note according to the tuning used, which is either two in unison to



HIGHLAND BAGPIPE.

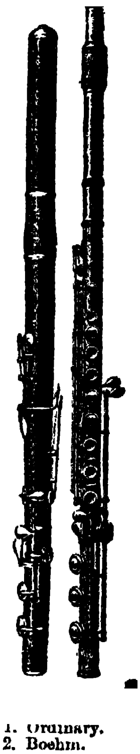


and the other an octave lower; or to G, D, G, or D, A, D. The ornamental notes produced are called "warblers." The IRISH BAGPIPE has a windbag inflated by means of a bellows worked by the arm. Its tone is softer, and it has a compass from

The drones are mounted all in one stock. This bagpipe is also called the UNION PIPES. Besides the foregoing there are the Northumbrian and other bagpipes.

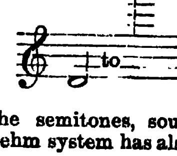
(2) The FLUTE is a tube made of cocoa-wood, ebonite, or silver, with either a conical or a cylindrical bore, and is played through a hole in the side about an inch from the head of the instrument. For this reason it was called *flauto traverso*, to distinguish it from the *flute à bec* or direct flute, now represented by the flageolet, an instrument which is fast disappearing. In *conical* flutes the head (top joint) has a cylindrical bore, which gradually decreases in size towards the end or foot joint. In *cylindrical* flutes the bore of the foot and body are cylindrical, but it tapers towards the top in the head joint. The flute has from about eight to twelve keys and a chromatic compass from

(or even down to B♭), but the two top notes are both difficult and harsh. Many systems of fingering are in use, the principal being that of Böhm (or Boehm), which allows of the more difficult keys being used with greater ease. Boehm also, in place of the old plan of boring the holes to suit the fingers, substituted (about 1834) a system of mathematically correct boring with special mechanism to suit this arrangement. The orchestral flute is a non-transposing instrument. There is also a flute in E♭ (often spoken of as the third flute in F, but tuned in E♭), which transposes a minor third higher (*see* CLARIONET); also a flute in B♭ (which should be more appropriately called in A), transposing a minor sixth higher; and a flute in E♭ (more appropriately in D♭), transposing a semitone higher. The flute is able to play very rapid passages, and is assigned the highest part in orchestral music.



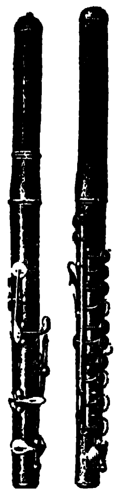
1. Ordinary. 2. Boehm.

The PICCOLO, or OCTAVE FLUTE, as its name implies, transposes an octave higher than the notes written. Its compass is from



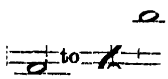
including all the semitones, sounding an octave higher. The Boehm system has also been applied to

this instrument. There are also piccolos in E♭ and F, transposing respectively a minor second and minor third higher, and should more appropriately be termed in D♭ and E♭.



Piccolos.
1. Ordinary.
2. Boehm.

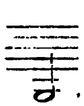
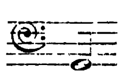
(3) The FRENCH HORN: A brass instrument of peculiar softness of quality, played by means of a circular mouthpiece. In shape it is spiral with a bell-shaped ending, into which the hand can be inserted to obtain certain sounds called closed notes. This instrument is played by means of different *embouchures* (different positions of the lips), which produce the series of natural harmonics. By means of "crooks" — smaller interchangeable tubing—it is possible to get the horn in any key. The compass of the horn in C is from



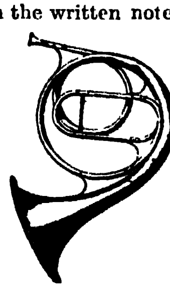
sounding an octave lower than written. All horns are transposing instruments. *See* CLARIONET. The following is a list, with the transpositions:

Horn in B♭ alt.	A major 2nd lower	
A	A minor 3rd ,,	
A♭	A major 3rd	
G	A perfect 4th	
F	A perfect 5th	These crooks are the most effective for both hand and valve horns.
E	A minor 6th	
E♭	A major 6th	
D	A minor 7th	
C	An octave ,,	
B basso	A minor 9th ,,	
	A major 9th ,,	

Horns can also be "crooked" in G♭ and D♭, thus giving a complete set. It may here be noted that music for the horn is written in the treble clef, except for the lowest notes, which are *sometimes* written in the bass clef. When this latter clef is used, the notes are written an octave lower than they would be in the treble clef. *e.g.*

 would be written  not 

From this it will be seen that the actual sounds of all horns above C are lower than the written notes when the treble clef is used, and higher when the bass clef is used; whilst the horns in C, B basso, and B♭ basso are higher when the treble clef is used, and lower when the bass clef is used, excepting the horn in C, which is correct when the bass clef is used. Music for the horn is always written in the key of C, prefixing which horn is to be used, *e.g.* Horn in D, Horn in F, etc.; and as most


French Horn.

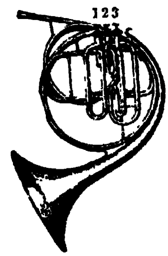
orchestras have either two or four horns, these are generally in different keys, so as to enable a greater number of open notes to be used. Other notes than the harmonics can be obtained by inserting the hand into the "bell"; these are called "closed" notes, and have a great difference in tone, being less brilliant. The following shows the notes obtainable on the hand horn in F, the closed notes being written as crotchets, and those obtained by inserting the hand farther into the bell, and called double closed notes, are written as quavers:

Written notes.

(*a*) This note is better when taken as a double stopped note from the tone above (c).

* These four notes, says Berlioz in his *Treatise on Orchestration*, are bad, dull notes.

The loss of a complete chromatic scale on this most interesting instrument led to the introduction of valves or ventils. This instrument is known as the VALVE HORN. By pressing the finger on a valve, it opens and thus lengthens the tube. It has a distinct advantage over the hand horn; for firstly it produces the same tone and notes as the latter instrument if the valves are left untouched (and composers, whenever they wish a note to be played as on the hand horn, have only to mark the note or notes *bouchée* or by some other sign); and, secondly, it has a chromatic scale of even quality. To the valve horn are attached three valves—ventils or pistons (*see* illustration), the first finger lowering the note a tone, the second finger lowering it a semitone, and the third finger lowering it a tone and a half. These can be used in combination, *e.g.* the first and third will lower a note two and a half tones. The following shows the notes obtainable with the fingering of the valve horn in E♭. The open notes are left



Valve Horn.

unfingered, and where more than one finger is put, these are to be used in combination.

(*b*) These notes, if marked *bouchée*, can be played as stopped notes, and those marked (*c*) as double stopped notes, as on the hand horn.

The actual sounds are a major sixth lower than those written. The French horn is one of the most difficult of wind instruments, and it is advisable in writing orchestral music to limit the compass of the first horn by not going below

, and by not going above 

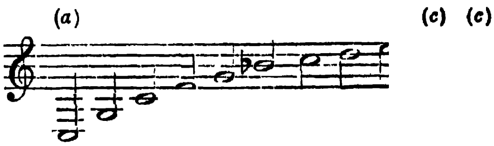
for the second horn. It is only necessary to add that the horns in D and C exceed the compass given above by five semitones, going to

whilst those in B♭, A, A♭, and G do not go above 

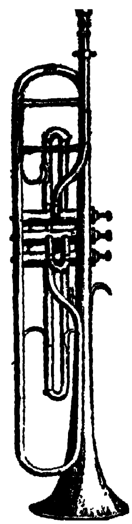
and that in B♭ basso only has a compass from

The **Tenor Cor** may be termed "the amateur's French horn." It has a mouthpiece of the saxhorn type, and is conical from the mouthpiece. It is very much easier to play than the French horn. In shape it is similar to the French horn, but it is held in the reverse manner, the right hand fingers being on the pistons and the left hand holding the bell. Its compass is the same as the French horn.

Trumpet (Tromba): The trumpet is a cylindrical brass instrument curved and ending in a "bell." It is played by means of a cup-shaped mouthpiece, shallower than that used in the cornet, and has a brilliant, penetrating tone. Like the horn, the sounds produced by means of different positions of the lips, called *embouchures*, are the natural harmonics. To increase these harmonics "crooks" (*see* Horn) are added, thereby giving the series from different foundation notes. The crooks in use are the F, E, E♭, D, C, and B♭. With the exception of the C crook all these are transposing instruments (*see* Clarionet), those in F, E, E♭, and D sounding higher, and those in B♭ and A a tone and a tone and a half lower respectively than the notes written. The notes obtainable on the D and D♭ trumpets are:



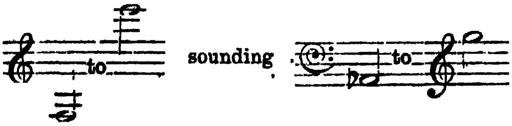
the actual sounds being a tone and a semitone higher respectively. The note marked (*a*) cannot be obtained on the C, B♭, and A crooks, nor those marked (*c*) on the F, E, and E♭ crooks, except by very accomplished players. The F♯ is obtained by somewhat overblowing the naturally too sharp F, which therefore is omitted. This limited series of notes accounts for the use the great masters made of this instrument, *viz.* chiefly for rhythmical effects. Bach and Handel wrote their trumpet parts, using notes up to



Valve Trumpet.

or even higher; but with the present mouthpiece these notes are extremely difficult of production. To meet this difficulty and avoid the deplorable custom of substituting cornets for trumpets, Messrs. Mahillon & Co., of London, have constructed a new instrument with a special mouthpiece, which they have called a "Sopranino Trumpet in Upper D," and which enables these highest notes to be produced with comparative ease. Trumpets are also constructed in upper B♭, with the same fingering as the cornet in B♭, and are extensively used in Paris, Brussels, Berlin, etc. Unlike the horn, the trumpet bell will not allow of the hand being inserted for closed notes. To increase the usefulness of the trumpet, valves have been added, as in the case of the horn, and the natural trumpet has been completely superseded by the **Valve Trumpet**, which becomes a melodic as well as a rhythmical instrument, having a complete chromatic scale throughout the compass shown above for the natural trumpet. These valves are explained above in the horn. Modern composers write for the valve trumpet, and use chiefly the most effective crooks, *viz.* F, E, and E♭, the first of these being most used. Besides this instrument, there is also a slide trumpet, but its intonation is not so certain. The effect of the slide is explained under **Trombone**. Music for the trumpet is written in the key of C and in the treble clef, directions being prefixed as to which crooks are to be used, *e.g.* Trumpet in F. Wagner used trumpets

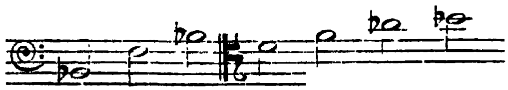
in E♭ basso and in D and C basso. This trumpet in E♭ basso has a chromatic compass from



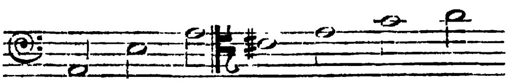
and by extra crooking those in D and C basso are obtained.

The **Trombone** consists of a twice bent tube with a bell shaped ending, made in the middle in such a manner that the slide (outer section) can move on the inner section. Like the French horn, the notes obtainable are the natural harmonics, and by extending the slide (which is held in the player's right hand) to the different positions, this set of harmonics can be repeated in different degrees, each a semitone below the other. Below are given the harmonics produced in the first and second positions of the tenor trombone; the remaining five positions can easily be found by transposing the series of harmonics a semitone lower for each position.

Harmonics produced in first (or "home") position.

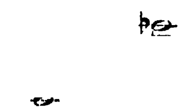


Harmonics produced in second position.

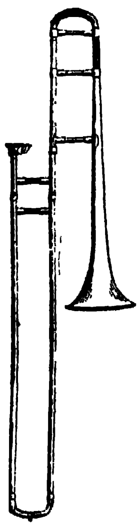


In the first four positions a note an octave lower than the first given above can be produced. These notes are called pedal notes. There are three trombones: the alto in E♭, with a chromatic compass from

the tenor in B♭, with a chromatic compass from



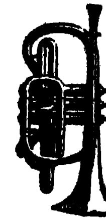
and the bass in G or in F, with a chromatic compass from



Slide Trombone.

Besides the slide trombones, there are the valve trombones, which have the same compass respectively, and are easier to learn. Trombones are largely used in the orchestra on account of their beautiful effect in both *piano* and *forte* passages, the tone being noble and rich; splendid examples can be found in Mendelssohn's scores. Trombones are non-transposing instruments, and the music is written in the alto, tenor, and bass clefs respectively.

Saxhorns:—The Cornet: A brass instrument with a cup shaped mouthpiece; it has three valves, working as in the valve French horn (*q.v.*) The tone is less brilliant than that of the trumpet, and its execution less difficult. The cornet may be called the treble of the saxhorn family. When trumpets cannot be obtained the cornet is used as a substitute. Cornets in B♭ and A are generally used, but by using crooks other keys are obtainable. With the exception of that in C, cornets are transposing instruments (*see* Clarionet), sounding lower than the written notes. It has a chromatic compass from

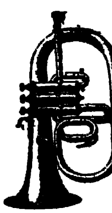


Cornet.

(written notes)

There is also a soprano cornet in E♭, transposing a minor third higher. Music for the cornet is always written in the treble clef. For fingering *see* Flugel Horn.

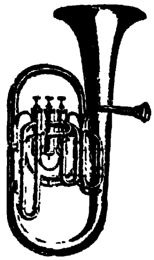
The Flugel Horn is treated the same as the cornet; but it has a much larger bore, being more like the bugle. Its compass is the same as the cornet. It is made in B♭, having three valves. The following is the fingering on the flugel horn, and, the compass being the same on the two following instruments, the fingering on those (as well as the cornet) is identical. The notes in semibreves are open notes, and the last three notes should be sparingly used:



Flugel Horn.

The flugel horn is a transposing instrument (*see* Clarionet), the actual notes being a tone below.

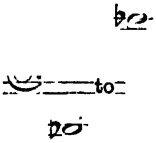
The SAXHORN or TENOR HORN in E♭ is the next of the saxhorn family. Its compass is a perfect fifth below that of the flugel horn. The saxhorn is used in combination with or as a substitute for the French horn, but the latter instrument is decidedly finer in tone. Besides the E♭ there is an F crook. Both are transposing instruments (*see* CLARIONET), the actual notes being a major sixth and perfect fifth below respectively. The fingering is given above. *See* FLUGEL HORN.

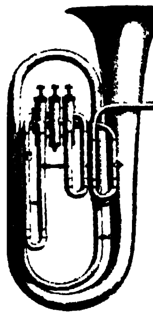


SAXHORN OR TENOR HORN IN E♭.

The BARITONE in B♭ is the next of the saxhorn family. Its compass is an octave below the flugel horn. It is a transposing instrument (*see* CLARIONET), the actual notes being a major ninth below. The fingering is given above. *See* FLUGEL HORN.

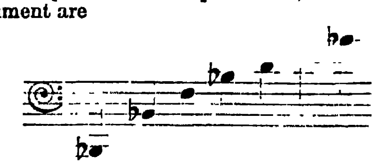
The EUPHONIUM is a brass instrument, usually with four valves, belonging to the saxhorn family. It is the bass soloist of the military band, having taken the place of the ophicleide, which in its turn took the place of the serpent. It is a non-transposing instrument, and has a chromatic compass of three octaves, from



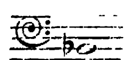


BARITONE.

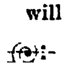
Besides the shape given in the illustration, there is a circular euphonium. Music is written in the bass clef. The valves, as explained above in valve horn, lower the pitch of the open notes, which on this instrument are



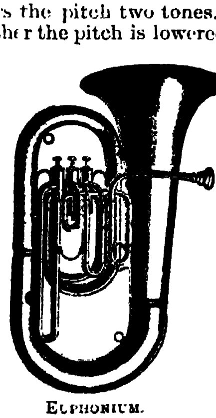
as follows: First, a tone; second, a semitone; third, one and a half tones; fourth, two and a half tones. (Abroad the third valve lowers the pitch two tones.) By using the four valves together the pitch is lowered five and a half tones. It will thus be seen that by using the four valves this note



will give



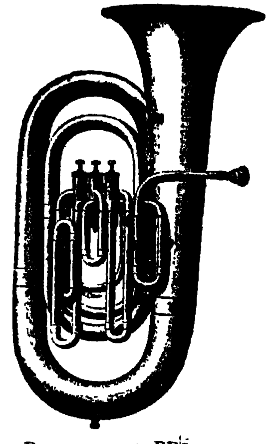
the second note in the chromatic compass of the euphonium.



EUPHONIUM.

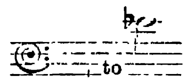
The TENOR TUBEN and the BASS TUBEN are brass instruments, partly cylindrical and having a longer and narrower bore than the euphonium: the tenor is in B♭ and the bass in F, and each has four valves. The compass of the tuben is from

the tenor sounding a major second lower, and the bass a perfect fifth lower than the written notes. The tuben may be said to have been invented by Wagner, who used them in his works; for instance, in the *Trauer-marsch* in the *Götterdämmerung*.

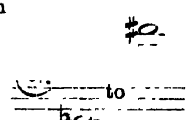


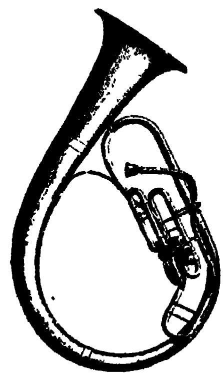
BOMBARDON IN BB♭.

BOMBARDON, the lowest of the saxhorns, is of two shapes: one like the euphonium, but larger; the other circular, encircling the body and resting on the shoulder of the performer. They have mostly three valves (occasionally one with four valves is found), and are of two pitches, the E♭ and the BB♭. These, with the stringed double basses, are the lowest instruments in the military band. The chromatic compass of the E♭ bombardon is from



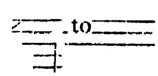
those with four valves going down to E♭ three octaves, and of the BB♭ bombardon from





NEW MODEL CIRCULAR BOMBARDON.

The music is written in the bass clef, bombardons being non-transposing instruments. The BASS TUBA is a species of bombardon having a noble tone. It is a non-transposing instrument, and has the largest compass of orchestral instruments, *viz.* from



or even descending to a fourth below. Music for the bass tuba is written in the bass clef. *The illustrations of the cornet, flugel horn, tenor horn in E♭, baritone in B♭, euphonium, and bombardon show the relative sizes of the saxhorns.*

(4) The **Organ**: This is by far the most important of wind instruments played by means of a keyboard, and only a very brief description of the various parts of the construction can be given. The accompanying illustration (fig. 1) shows the several parts leading from key to pipe. At the back of the key (1) is inserted an upright rod called a sticker (2), running up through one end of a lever or backfall (3); the other end of this lever falls when the key is depressed, pulling down the tracker (4), which is fixed to one arm (5) of the roller. Rollers are used to reach the pallets, which are generally out of the vertical line of the action from the keys. They consist of metal rods turning on pins and having a short arm at each end (fig. 2). The tracker from the backfall is fitted to one arm, and to the other arm is fitted the pull down wire (6), which is moved when the tracker gives the roller the necessary movement. The pull down wire opens the pallet (7), allowing the wind to pass from the wind chest (8) to the grooves (9) in the sound board, over which the pipes stand. The pallet is supplied with a spring (10) to close it immediately the key is released, and so restore the action to its original position. Besides rollers, *squares* of wood or brass are used for carrying the action from key to pallet. In addition to the foregoing action, which is called the **Tracker Action**, there is the **Pneumatic Lever Action**, which sometimes is applied to the whole of the keys, and at other times only to the lowest octave. This consists of a small bellows attached to the pull down and pallet, which is filled by compressed air when the key is played, thereby opening the pallet, and is emptied when the key is released, allowing the pallet to close. This action is much lighter to the touch

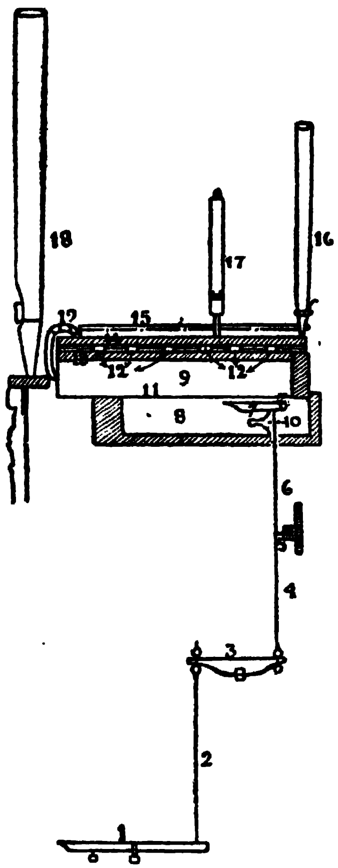


Fig. 1.

1. Key.
2. Sticker.
3. Backfall.
4. Tracker.
5. Roller arms.
6. Pull down wire.
7. Pallet.
8. Wind chest.
9. Grooves.
10. Pallet spring.
11. Sound board.
12. Sliders.
13. Table.
Upper board.
15. Pipe rack.
16. Reed pipe.
17. Stopped wood pipe.
18. Open metal pipe.
19. Conveyance taking wind to pipes on different level.

than the tracker. A third action is the **Tubular Pneumatic Action**, which does away with the use of trackers—tubes connecting the key and the small bellows under the pallet. The wind is admitted to this tube when the key is depressed, and carried to a small circular chamber covered by a disc of leather called a "puffer." This puffer, being lifted by the wind, operates a small pneumatic bellows connected with the sound board pallet. When the key is released the reverse action takes place, thus allowing the pallet to close. A fourth action is the **Electro-Pneumatic**. In this action, instead of the pulse of compressed air through the long tube, electricity is used. By depressing the key contact is formed, and the current passes through a small electro-magnet, which, attracting an armature, opens the valve that operates the pneumatic action. With these two last actions the **Console** (consisting of the manuals, pedals, draw stops, accessories, etc.) can be carried to a distance from the instrument proper, allowing the organist to judge better the effect produced by the organ. The accompanying illustration (fig. 3) shows the console of an electro-pneumatic organ built in 1888 by Messrs. J. W. Walker & Sons, London, the cable on the left connecting to organ. The upper part of the wind chest is called the **Sound Board** (11, fig. 1). Each set of pipes is known as a **Stop**, and is brought into action by a draw stop being drawn out. This in turn draws into position the corresponding **Slider** (12). The draw stops are placed at the right and left of the console, each bearing its name (it should also bear the pitch) on the knob. The slider, or slide, is a perforated flat strip of hard wood which covers and uncovers the holes in the upper surface of the board above the channels of the sound board, called a **Table** (13), and below the **Upper Board** (14), which supports the pipes. This upper board is also perforated with corresponding holes. By drawing the draw stop the slider is drawn into such a position that the holes in the table, slider, and upper board are over each other, thus allowing the wind to pass to the pipes when the pallets are opened. When the draw stop is in, the slider shuts off the wind between the table and upper board. Should the wind from some defect be not properly shut off from the pipe, this is known as a **Ciphering**. The pipes are placed as a rule in succession a tone apart, having the two largest pipes at the two ends of the sound board, the position being: Bass end, C, D, E, F♯, G♯, A♯, C, etc.; treble end, C♯, D♯, F, G, A, B, C♯, etc., so working towards the centre with the smallest pipes placed there. The pipes are held in position by a framework placed a few inches above the upper board, known as the **Pipe Rack** (15). The **Bellows** are the lungs of the organ, and consist of (*a*) the **Feeders**, which are operated by the blowing handle, (*b*) a **Bottom Board** perforated with holes, through which the air, compressed by the feeders, passes into (*c*) the **Reservoir**, which is kept filled by the feeders. The holes in the bottom board are covered by leather pallets, which prevent the air returning into the feeders from the reservoir. From the reservoir of the bellows the wind is taken either direct or through intermediate reservoirs to the wind chest of the sound board by wind trunks, which are ducts of wood or zinc. The reservoir is weighted so that the wind supplied to the pipes may be

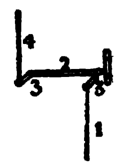
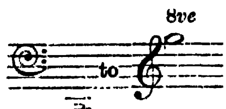


Fig. 2.

1. Tracker.
2. Roller.
3. Roller arms.
4. Pull down wire.

compressed. The pressure varies in different organs, $2\frac{1}{2}$ to 4 in. being the most usual when only one pressure is used; but many organs have the reeds and other portions of the stops on varying pressures, even up to 25 in. The **Manuals** are the sets of keyboards played by the hands, and are placed one above the other, but somewhat overlapping. *See* fig. 3. In organs with only one manual, that manual is called the **Great Organ** (*Hauptwerk*, in German; *Grande Orgue*, in French), and the pipes of the great are of large scale and full tone. If there are two manuals, the lower is the great and the upper the **Swell Organ** (*Oberwerk*, German; *Recitatif*, French). In the swell, all the pipes acted on are in a box which is fitted with Venetian shutters. These shutters are opened and closed by means of a swell pedal fixed above the pedals, thus giving a crescendo and decrescendo in the tone. These pipes are of smaller scale, and several are of the reed class. In three-manual organs the third manual is placed beneath the two former and is called the **Choir Organ** (*Positiv*, German; *Positif*, French); these pipes are of a soft character, and are intended for accompanying the choir in the softer passages. In four-manual organs we find, above the former three mentioned, the **Solo Organ**, having chiefly pipes of a solo character; whilst above this solo organ a fifth manual is sometimes placed, called the **Echo Organ**, the pipes of which are of a delicate nature and placed in a swell box. Besides these keyboards there is on all organs another keyboard played by the feet, and called the **Pedals**. *See* fig. 3. In the pedal organ are pipes forming a bass suitable to the different manual stops, and of lower tone. The pedal keyboard is either radiating, concave, radiating and concave, or concave and straight. The pedals generally consist of thirty notes, corresponding to the lowest thirty notes of the manuals, and as the foundation tone of the pedals is 16 ft., these notes are spoken of as CCC to F. The compass of the manuals varies from fifty-six notes



(CC to g^2)

to five octaves

(CC to c^3)

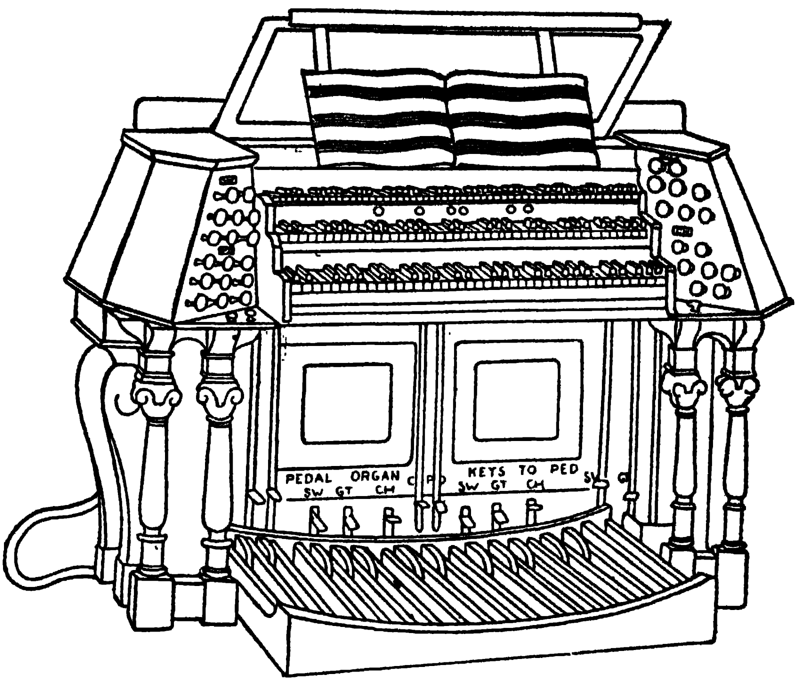


Fig. 3.—Moveable Console of an Organ.

The draw stops of each organ are generally arranged in the following groups:

Left Side of Console.	Right Side of Console.
Swell organ.	Solo organ.
Pedal organ.	Great organ.
Couplers.	Choir organ.

Speaking stops are divided into Foundation, Mutation, Compound, and Reeds. Some of the most usually found are:

Foundation Stops (Manual).

16 *ft. tone, i.e. sounding an octave lower.*

Double open diapason .	Metal; open.
Contra gamba . . .	Metal; open, slotted.
Double stopped diapason .	Wood; stopped.

[Stopped pipes are those having a plug in the top (*see* fig. 5), and being of only one-half the length of an open pipe, yet give the same sound as the open pipe.]

8 *ft. tone, i.e. sounding the same pitch as a pianoforte.*

Open diapason . .	Metal; open.
Violin diapason or Geigen principal	Metal; open, small scale, stringy.
Horn diapason . .	Metal; open, reedy.
Gamba . . .	Metal; open, slotted, reedy.
Echo gamba . .	A small scale gamba.
Keraulophon . .	Metal; a species of gamba.
Salcional (salicional)	Metal; open, small scale.
Dulciana . . .	Metal; open, very small scale.
Rohr flute . . .	Metal; stopped with a hole in the stopper.
Stopped diapason .	Wood; stopped.

Lieblich gedact	Wood; "sweet" toned and stopped.
Clarabella . .	Wood; open.
Hohl flute . .	Wood; open.

4 ft. tone, i.e. sounding an octave higher.

Principal . .	Metal; open.
Gemshorn .	Metal; open.
Harmonic flute	Metal; of 8 ft. length with a hole midway, causing sound to be of 4 ft. pitch.
Lieblich flute	Wood or metal; "sweet" flute.
Wald flute	Wood; a species of clarabella.

2 ft. tone, i.e. sounding two octaves higher

Fifteenth . . .	Metal; open.
Piccolo . .	Metal or wood; open.
Flautina	Metal; a species of fifteenth.

Mutation stops are those which give a different sound than octaves and doubles to that played, such as the Twelfth, which is of metal, and sounds the twelfth note above. Compound stops are those which have more than one pipe to each key, such as the Mixture of different ranks. *See* MIXTURE. All the above stops are called the FLUEWORK. The late Dr. E. J. Hopkins says: "All organ stops in which the sound is produced by the wind passing through a flue or windway and striking against an edge above, belong to the fluework, whatever may be the shape, make, or tone of their pipes" (Sir George Grove's *Dictionary of Music and Musicians*). The accompanying illustration (fig. 4) shows a metal

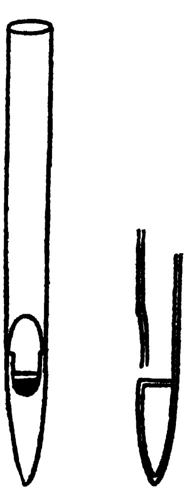


FIG. 4.

FIG. 5.

pipe and a sectional view of the same; fig. 5 shows a stopped wooden pipe and a sectional view of the same. The Reeds are the Double Trumpet, Trombone, and Contra fagotto of 16 ft. tone; the Trumpet, Posaune, Cornopean, Horn, Oboe, Clarionet of 8 ft. tone; and the Clarion of 4 ft. tone. With the exception of the three 16 ft. reeds, which are made of metal or wood, these are all metal pipes. The accompanying illustration (fig. 6) shows a reed pipe with and without the "boot." In the Town Hall, Sydney (N.S.W.), organ, which is the largest in the world, having 5 manuals with 28 stops on the great, 24 on the swell, 20 on the choir, 20 on the solo, 8 on the echo, and 26 on the pedal, besides 14 couplers, there is on the pedal organ a unique 64 ft. reed (contra trombone), the longest tongue being 2 ft. This organ contains 10,250 pipes, weighs 100 tons, and was built by Messrs. W. Hill & Son, London. Besides the above stops, there are the *vox angelica*, which consists of two ranks of pipes of the dulciana type, one of which is tuned sharper or flatter than the other; the *voix celestes*, or *unda maris*, which consists of two ranks of the gamba type tuned like the *vox angelica*. The *vox humana* is a reed of very small length, capped, and is always used with the tremulant. The tremulant acts on the supply of wind in such a manner as to disturb the steady supply, causing a throbbing sensation. Tremulants are of many patterns.

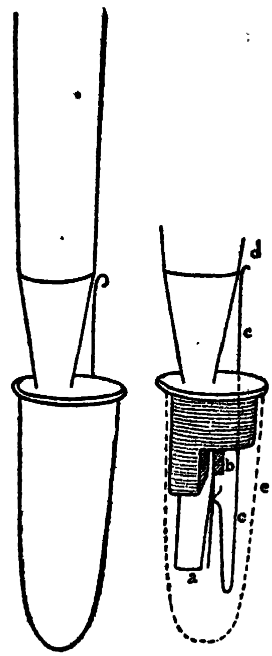


FIG. 6.
(*a*) Reed of hollowed brass, and slightly curved "tongue."
(*b*) Wedge.
(*c*) Tuning spring.
(*d*) Pipe (*e*) The boot.

THE PRINCIPAL PEDAL ORGAN STOPS ARE:

Of 32 ft. tone, i.e. sounding two octaves below.

Contra trombone (reed) .	Wood or metal.
Double open diapason . .	Wood or metal.
Sub-bass or sub-bourdon .	Wood (16 ft. stopped).

Of 16 ft. tone.

Trombone or posaune (reed)	Wood or metal.
Open diapason	Wood or metal.
Violone	Metal (small scale).
Bourdon	Wood (8 ft. stopped).

Of 8 ft. tone.

Trumpet (reed)	Metal.
Violoncello	Metal.
Principal	Metal or wood.
Flute	Wood (or 4 ft. stopped).

Of 4 ft. tone.

Viola or fifteenth . .	Metal.

On some organs, instead of thirty pipes to each stop, an extra octave, making forty-two pipes, is placed to each stop, and an octave coupler added, thus giving a "duplication" of each stop in the octave above at the same time. Another and better plan is to have the forty-two pipes with a separate draw stop to each, one acting on the lower thirty pipes and the other on the upper thirty pipes—*e.g.* bourdon, 16 ft.; flute, 8 ft. In the former case the lowest note on the pedals would open the pallet of the lowest pipe, whilst in the latter the lowest note on the pedal would open the pallet of the octave above, and the highest octave

of the pedals would call into use the extra twelve pipes. The accompanying illustration (fig. 7) shows the lower portion of a pedal open diapason pipe (wood). The ACCESSORY (NON-SPEAKING) STOPS are mechanical contrivances for connecting the different manuals, such as swell to great, swell to choir, solo to great, and cause the corresponding notes of the coupled manual to speak when those notes are played on the manual to which it is coupled. There are also octave (super-octave) and sub-octave couplers, which make the note an octave above or below respectively speak at the same time as the note is depressed. Pedal couplers connect the pedals and manual, and are called great to pedal, choir to pedal, swell to pedal, solo to pedal. COMPOSITION PEDALS consist of iron pedals placed over, but clear of, the pedal board. By varying forms of mechanism these control the stops of the organ, *i.e.* throw them out or in, or out and in, in set combinations. A recent mechanical contrivance enables the organist to arrange the combinations of stops drawn by the composition pedals at the keyboard. This is known as "interchangeable combination." Because these composition pedals, when set, not only throw out the arranged set of draw stops, but at the same time throw in all other stops on the manual to which the pedal belongs, they are known as "double-acting." Composition pedals are generally arranged in progressive order from left to right: (1) *p*; (2) *mf*; (3) *f*; (4) *ff*; those over the lower half of the pedal board acting on the swell organ, those over the upper half acting on the great organ. In some organs, instead of composition pedals, ventils are used, which, until drawn, cut off the wind from certain stops, whether the draw stop is in or out. PNEUMATIC PISTONS are also placed between the manuals (fig. 3) to alter the stops, and have the same effect as composition pedals. When pistons are used some of the composition pedals usually act on the pedal organ stops. Occasionally a crescendo or sforzando pedal is added, which, without altering the stops, brings on the whole of the power of the instrument, either gradually or suddenly, as required. In the Hope-Jones electric organ console, stop keys are placed over the top manual, which when depressed are brought into action, and when raised are thrown out of action. These stop keys are distinguishable by different colours. The nomenclature of the stops, too, is different. The stop keys take the place of draw stops, the latter being entirely done away with. SECOND TOUCH—somewhat similar to the double touch in a Mustel organ (*q.v.*)—is also introduced. Fuller information on the subject can be obtained in *The Organ: Its History and Construction* (Hopkins & Rimbault); *The Art of Organ Building* (Audsley).

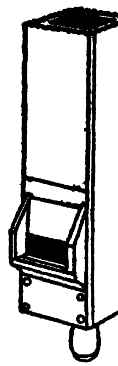


FIG. 7.

The HARMONIUM: This is the most modern of keyed instruments, dating from about 1840 (the American organ, which may be said to be a modified harmonium, was introduced about twenty years later). The harmonium is supplied with compressed wind from a reservoir, which is fitted with a strong spring to resist the expansion caused by the wind supplied to it by feeders worked by the feet of the performer, which are placed on treadles (pedals). The reservoir spring takes the place of the weights on the organ reservoir. A safety valve in the shape of a pallet is placed in the reservoir to minimise over blowing. Above the reservoir is the wind chest, covered by the bellows board, containing valves, which permit the wind to reach the different sets of reeds as the stops are drawn. The reeds are tongues of brass of various thicknesses and lengths, screwed at one end to a metal plate, with apertures over which the tongues vibrate without entirely closing the aperture; hence they are called FREE REEDS, whilst those in the organ are STRIKING REEDS. The apertures are closed by pallets held down by springs, and connected by levers to the keys. When the key is played the pallet is opened, and allows the wind, when a stop is drawn, to pass through the reed aperture at an even pressure, unless a stop called the "Expression" is drawn, which allows the wind to come direct from the feeders. The performer in this case is able to increase or decrease the sound according to the amount of wind supplied by the feet to the feeders. The harmonium has a compass of five octaves, from

whilst that of the American organ is a perfect fifth lower:

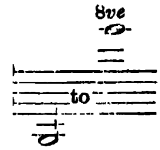
The AMERICAN ORGAN differs chiefly from the harmonium in having the wind drawn in through the reed apertures, whilst in the latter instrument it is blown out. The tone of the former is less harsh than that of the harmonium, which has a more characteristic tone and greater advantages. Harmoniums vary very much in the number of stops. These are placed in three groups: those on the left consisting of sounding and mechanical stops acting on the keys below

those on the right likewise consist of sounding and mechanical stops acting on the keys from and above this note; those in the centre group are mechanical stops only. The two groups of sounding stops are generally similarly numbered, showing which are complementary stops, giving the same quality and pitch throughout the entire keyboard. Some of the most generally found are:

Left hand.	*Right hand.*	*Pitch.*
Cor Anglais, 1.	Flute, 1	8ft. tone. *See* ORGAN.
Bourdon, 2.	Clarionet, 2 .	16 ft. tone.
Clarion, 3.	Fifre or Fife, 3.	4 ft. tone.
Bassoon, 4.	Oboe, 4 . . .	8 ft. tone (reedy).

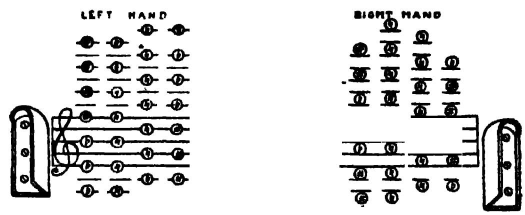
The above is a harmonium with four "sets" of reeds. Other stops are: *Harpe eolienne*, 2 ft. tone, which consists of two half sets of reeds slightly out of tune with each other, producing a waving tone and acting on the lower half of the instrument. *Voix celeste*, 16 ft. or 8 ft. tone, consisting of two half sets of reeds slightly out of tune with each other. *Musette*, 16 ft. tone (reedy). *Barytone*, 32 ft. tone, somewhat like the *musette*. These last three stops act on the upper half of the instrument. The MECHANICAL STOPS are: The *fortes*, which open shutters above the reed box, allowing more sound to escape from whichever half happens to be drawn. *Sourdine*, which shuts off part of the wind on the lower half of the keys, thus giving a softer tone. *Tremolo*, which sets up an unsteady supply of wind. The *Percussions*, which call into play a somewhat similar action to that of the pianoforte, a small hammer striking the Cor Anglais and flute reeds at the moment the key is played, thereby giving an emphasis to the tone. *Grand jeu* (full organ), which when drawn calls into action all the reeds, except the *voix celeste* and *harpe eolienne*, thus giving the full power of the instrument. *Expression*, the most important of the mechanical stops, has been explained above, and gives the performer immense opportunities of bringing out the light and shade of this much neglected instrument. Different *couplers* are also found, and have much the same effect as the couplers on the organ. The result obtainable is placed on the stop label of each. Under the keys knee levers are often fixed. That on the right, when pressed outwards, opens a swell producing a crescendo, whilst that on the left brings into action the *grand jeu*. Sometimes the levers are the reverse of the foregoing, at other times each lever acts as a crescendo on its respective half of the instrument. When there is only one lever it is generally in the middle of the instrument, and brings on the *grand jeu* when pressed to the right, a spring allowing it to recover when the knee is withdrawn. The harmonium has the great advantage of keeping longer in tune than either the organ or pianoforte, and deteriorates very slowly, and deserves much greater attention being paid to it as a solo instrument. An account of the harmonium would be incomplete without a few words concerning the instrument brought to such wonderful perfection by M. Mustel, and bearing his name, "The Mustel organ." On this instrument the percussion is brought to a state of perfection, allowing the most rapid music to be performed, and giving that effect to the stops which "lipping" does to wind instruments. To these organs is also added a *metaphone*, which consists of three Venetian shutters placed immediately over the sound openings of Nos. 3, 4, *musette*, *harpe eolienne*, and *barytone* reeds, softening and refining most of the stops. The metaphones are placed one at each end of the stops. The *double expression* acts on Nos. 3, 4, *musette*, *harpe eolienne*, and *barytone* admitting an extra pressure of wind. This and the expression stops should always be kept out, as the softest tone is instantaneously expressed. Double touch consists of a mechanical arrangement which, when the keys are pressed about a third of the distance down, causes the Nos. 3 and 4 reeds to speak, and when the key is further pressed down, Nos. 1 and 2 reeds also speak. This, it will easily be seen, allows of prominence being given to certain notes only.

The ENGLISH CONCERTINA was invented by Sir Charles Wheatstone (the inventor of the electric telegraph) about 1827. It is an expansible instrument, having a keyboard at each end with the bellows between. The wind from the bellows passes through apertures, causing free reeds to vibrate when a key is pressed. Concertinas are made in different sizes, shapes, and pitch. The treble has from 48 to 64 keys, the compass of one with 56 keys being either from

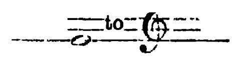


or four octaves from

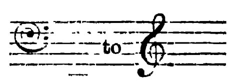
with all the semitones. The following illustration shows the position of the keys and the sound produced by each in the 56 keyed instrument:



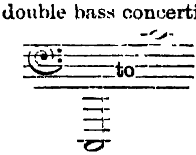
The position of the keys is kept the same in all the family of concertinas. The baritone compass is from



the bass compass is from

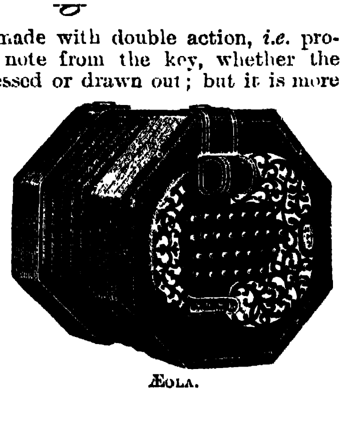


and that of the double bass concertina from



All these can be made with double action, *i.e.* producing the same note from the key, whether the bellows be compressed or drawn out; but it is more usual for the bass and double bass to have a single action.

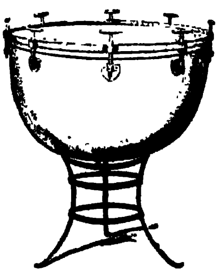
A new instrument of the same family has been brought out by Messrs. Wheatstone & Co., called the ÆOLA. It is octagonal in shape and of remarkably pure



ÆOLA.

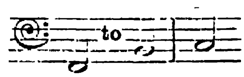
tone. The compass of the different æolas and the fingering are exactly the same as in the corresponding concertina. The best reeds are of highly tempered steel. Concertinas and æolas are now tuned on the equal temperament system, like other keyed instruments, and both brilliant scale passages and chords can be easily performed. A great quantity of music has been composed for this instrument, which is capable of producing combined sustained and staccato passages and giving fine effects of expression. A quartette of concertinas or æolas have between them nearly as extended a compass as a pianoforte.

INSTRUMENTS OF PERCUSSION are of two kinds: (A) Those giving a definite sound, comprising the kettle drums or tympani, the glockenspiel, the key harmonica, and handbells. (B) Those giving an indefinite sound, and used only for marking the rhythm, comprising the bass drum, the side drum, the tambourine, the cymbals, and the triangle.

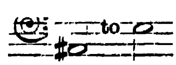


KETTLE DRUM.

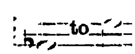
(A) The KETTLE DRUMS or TYMPANI are the most important of the percussion instruments, and consist of a metal shell, hemispherical in shape, with a head of vellum, held tightly in position by an iron ring, to which are attached screws to tighten or relax the vellum, thus tuning to any note within its compass. In the orchestra two or more drums are used, the larger having a chromatic compass from



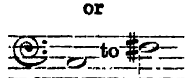
the medium from

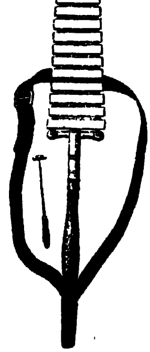


and the smaller a chromatic compass from



or

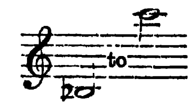




GLOCKENSPIEL AND BEATER.

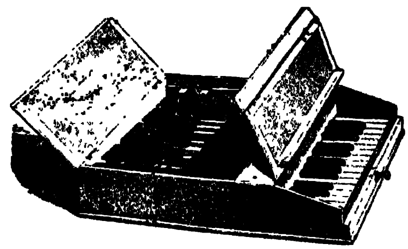
The vellum head is struck by a flexible wooden drumstick with ends of felt or sponge. It is usual now to write the actual notes to be played on the bass stave, but omitting the sharps or flats. The correct tuning, however, must be shown in the directions given at the beginning of, or during, the piece to be performed. Formerly the notation was always in the key of C.

The GLOCKENSPIEL or CARILLON is an instrument consisting of plates of steel, played by striking with beaters or by hammers set in motion by an action similar to the pianoforte. Originally a set of bells instead of steel plates were used. Its compass is from about

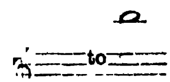


including all the semitones. The illustrations show a glockenspiel with beater and one with pianoforte action.

The KEY HARMONICA is similar to the glockenspiel, but the notes consist of plates of glass. Its compass is from about

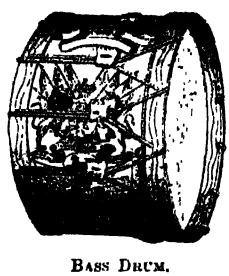


GLOCKENSPIEL OR CARILLON WITH PIANOFORTE ACTION.



HANDBELLS are hollow instruments made of metal, consisting of copper and tin, with at times small quantities of zinc, lead, silver, and antimony, struck by a clapper within, properly pegged to facilitate ringing. They are tuned to the chromatic scale, and a set ranges from 15 (two octaves) to 50 (four octaves).

(B) The BASS DRUM is a large cylinder with a skin head at each end, held in position by hoops. These skins are tightened by means of an endless cord passing round the instrument from hoop to hoop, and drawn together by leather braces. It is played by striking either or both heads with a wooden drumstick, the head of which consists of a series of layers of thick felt in the shape of a ball.

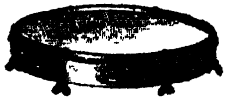


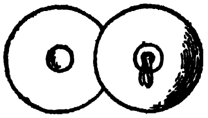
BASS DRUM.

SIDE DRUM.

The SIDE DRUM is a wooden or brass cylinder with a skin head at each end, as in the bass drum. It is played by striking the upper head, called the "batter," with two wooden drumsticks, the heads of which are uncovered. Across and outside the lower head passes a piece of gut called the "snare," four or more times across. When the upper head is beaten by the drumstick, the air in the cylinder is forced against the lower head, thus causing the snare to vibrate on the lower head, and give a sharp, crisp sound.

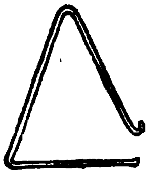
The TAMBOURINE: A wooden hoop with only one head of vellum, with metal "jingles" in pairs inserted at intervals round the hoop, which rattle when the instrument is shaken or played. There are two ways of playing the tambourine—one by striking it with the hand, the other by rubbing the vellum with the thumb or finger.


TAMBOURINE.


CYMBALS.

The CYMBALS: A pair of thin metal plates, somewhat of the shape of plate covers, which the player holds by a strap of leather running through the centre, one in each hand. They should be played by sliding one against the other, but not infrequently—although decidedly detrimental to the tone—one is fastened to the bass drum and the other held by the drummer in his left hand, and struck against it whilst playing the drum with the right hand.

The TRIANGLE: A rod of steel in the shape of a triangle, but with one angle not joined. It is played by striking it with a steel "beater."


TRIANGLE AND BEATER.

The division of the musical instruments into orchestral and military is shown under SCORE (*q.v.*) A drum and fife band generally consists of F piccolos, B♭ flutes, third flutes, side drums, bass drum, triangle, with the addition at times of cymbals, half the number in the band playing B♭ flutes.—W. W.

Musical Interval. *See* INTERVAL.

Musical Ornaments. *See* ORNAMENTS (MUSIC).

Musk (*Zool.*) An aromatic substance secreted in a glandular sac on the abdomen of the Musk Deer (*Moschus moschifera*), a native of the Himalayas and Central Asia.

Musket (*Arms*). *See* MUSQUET.

Musketoon (*Arms*). A rather short form of musquet (*q.v.*), with a wide bore; often bell-mouthed.

Musquet (*Arms*). A matchlock gun which succeeded the arquebus as a hand gun in the latter half of the sixteenth century, and was fired from the shoulder.

Mustard (*Botany*). The Cruciferous plants *Brassica nigra* (Black Mustard) and *B. alba* (White Mustard) yield the condiment, which consists of the ground seeds. Both species are common to Central and Southern Europe, and are also found in Southern Britain.

Mustard Oils (*Chem.*) The esters of isothiocyanic acid, CSNH. The most important of these is allyl isothiocyanate, $CSN.CH_2.CH:CH_2$, a colourless liquid having a very pungent smell, which causes tears; it blisters the skin; boils at 151°. Boiled with hydrochloric acid or heated with water at 200°, it yields allylamine.

$$CSNC_3H_5 + 2H_2O = CO_2 + SH_2 + C_3H_5NH_2.$$

It is prepared by distilling allyl iodide with an alcoholic solution of potassium thiocyanate. The natural oil of mustard is nearly pure allyl isothiocyanate. It is obtained from black mustard seeds, which are freed from oil by pressure, and made into a paste with water; now an aqueous extract of white mustard seeds is added. The black mustard seeds contain a glucoside called potassium myronate and also myrosin, an enzyme which hydrolyses the glucoside; the aqueous extract of white mustard seeds also contains myrosin. The reaction is:

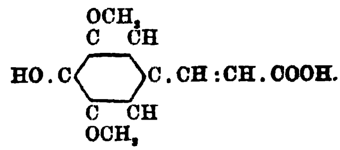
$$\underset{\text{Potassium Myronate (Sinigrin).}}{C_{10}H_{18}KNS_2O_{10}} = CSNC_3H_5 + KHSO_4 + \underset{\text{Glucose.}}{C_6H_{12}O_6}$$

White mustard seeds contain the glucoside sinalbin, which is hydrolysed by the enzyme myrosin as follows:

$$C_{30}H_{44}N_2S_2O_{16} = \underset{\text{Paraoxybenzylisothiocyanate (Sinalbin Mustard Oil).}}{CSNCH_2C_6H_4OH} + C_6H_{12}O_6$$

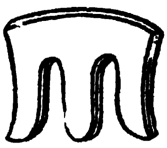
$$+ \underset{\text{Sinapine Sulphate.}}{C_{16}H_{24}NO_5HSO_4.}$$

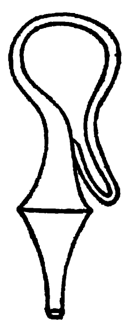
Sinapine is a compound of choline (*q.v.*) and hydroxy-4-dimethoxy-3 : 5-cinnamic acid.



Mutation Stops (*Music*). Those stops in an organ which give a different note (not octaves or doubles) from that played. *See* ORGAN.

Mute (*Music*). An instrument for deadening the sound in musical instruments. In the violin family it is made of different materials, and of various shapes, and is slotted in order that it can be fixed on the bridge; in the pianoforte the soft pedal acts as a mute. *See* SORDINI. Brass instruments are muted by a kind of leathern pear inserted into the bell, or by an additional valve which directs the column of air into a special bell, which has in its centre a chamber formed of two reversed cones with a small outlet at one end. The sound, being turned into the two reversed cones, comes out from the small aperture in a muted manner.


VIOLIN MUTE.


CORNET MUTE.

Mutual Induction (*Elect.*) The passage of lines of force through one circuit due to a current flowing through a second circuit. If a unit current flowing in one circuit causes l lines of force to pass through w turns of the second circuit, then $l \times w$ is called the COEFFICIENT of MUTUAL INDUCTION of the two circuits, and is denoted by M. Its value is the same whichever circuit the unit current flows in.

Mutule (*Architect.*) A projecting block worked on the soffit of the corona of the Greek, and sometimes of the Roman, Doric entablature. A number of guttæ are usually worked on the underside of each mutule. In Greek work there is usually a mutule over each triglyph and metope, the width of the mutule being equal to that of the triglyph; but in the Roman Doric order the mutules over the

metopes are omitted. *See* DORIC ORDER, ENTABLATURE, *and* ARCHITECTURE, ORDERS OF.

Muzzled (*Her.*) When an animal, *e.g.* a bear, is muzzled; if the muzzle is of a different colour it must be given.

Myrobalan (*Botany*). The astringent fruits of *Terminalia chebula* and *T. belerica* (order, *Combretaceæ*), trees growing in the mountainous districts of India. The fruit, which is a juiceless drupe, is extensively used in tanning and dyeing, and to some extent in medicine.

Myrrh (*Botany*). A gum resin obtained by exudation from the stem of a spiny shrub *Balsamodendron myrrha* (order, *Burseraceæ*). It is imported from Abyssinia and Arabia. Used in medicine and as an aromatic.

Myrtle. *See* WOODS.

N (*Elect.*) (1) The symbol for North or for the north seeking pole of a magnet. (2) A symbol often used for the magnetic flux (*q.v.*)

n (*Elect.*) A symbol often used for Frequency (*q.v.*)

Nadir (*Astron.*) A point or, more correctly, a direction immediately beneath the observer, and opposite to the zenith (*q.v.*)

Nagyagite (*Min.*) A telluride and sulphide of lead and gold. Also called black tellurium: orthorhombic. It usually contains some antimony, and the gold varies from 6 to 12 per cent. It is a dark lead grey sectile mineral. From Transylvania.

Naiant (*Her.*) A fish swimming straight across the field.

Nail Head (*Architect.*) A Norman moulding enriched with a series of pyramidal forms resembling nail heads.

Naissant *or* **Issuant** (*Her.*) An animal rising or issuing from the middle of an ordinary.

Naked Eye (*Astron.*) When an object is observed without any aid, such as glasses, it is said to be observed with the naked eye.

Naked Floor (*Carp. and Join.*) The floor joists without the boards.

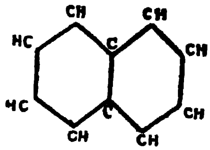
Naked Forme (*Typog.*) A form that has been stripped of its furniture (*q.v.*) preparatory to distributing the type, or one around which the furniture has not yet been placed.

Naos (*Architect.*) *See* CELL.

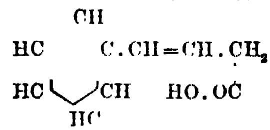
Nap (*Textile Manufac.*) A heavy cloth of the frieze character used for overcoatings; but the naps or curls of fibres are more dense than in the frieze. *See* NAPPING.

Naphtha (*Chem.*) A term originally applied to rock oil, that is, oil issuing from the earth; then it was applied to fractions of these oils boiling up to 170°, or about that. Now it is applied at random to mixtures of hydrocarbons and other compounds from the most varied sources; *e.g.* bone naphtha from bone oil, solvent naphtha from wood tar, mineral naphtha from petroleum.

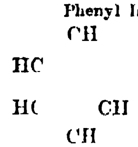
Naphthalene (*Chem.*)



A white solid which crystallises in plates; melts at 80°; boils at 218°; readily volatilises; distils in steam; insoluble in water; soluble in all the ordinary organic solvents, such as alcohol, ether, benzene, toluene, acetic acid. It has a characteristic smell, and is a valuable antiseptic, and is very objectionable to many insects—hence its use in preserving clothes and skins from the ravages of moths, etc. Technically it is used in the preparation of many dyes, *e.g.* Congo red, indigo, and many others (*see* under the various naphthalene derivatives); in increasing the illuminating power of coal gas, as in the albo carbon light, where coal gas is made to pass over melted naphthalene, and of water gas. It is obtained from coal tar, which contains 8 to 10 per cent. of it: for the method *see* GAS MANUFACTURE. Naphthalene derivatives have been synthesised from benzene derivatives by methods which show that naphthalene must have the constitution given in the above formula; *e.g.* if benzaldehyde is heated with sodium succinate and acetic anhydride at 125°, PHENYL ISOCROTONIC ACID and PHENYL PARACONIC ACID are obtained: these can be separated by carbon disulphide, in which the former is soluble.

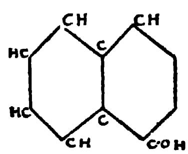


Phenyl Isocrotonic Acid.

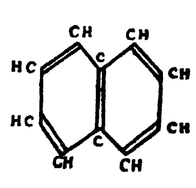


Phenyl Paraconic Acid (this acid really forms the lactone).

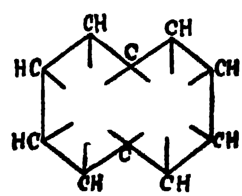
The former on long boiling with water gives α-NAPHTHOL—



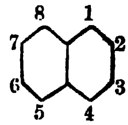
The formula given for naphthalene above is the one which will be used in describing the naphthalene derivatives: it does not account for the fourth combining unit of each of the carbon atoms. Two formulæ are in use for this purpose:



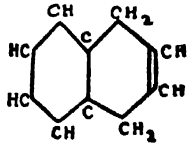
and



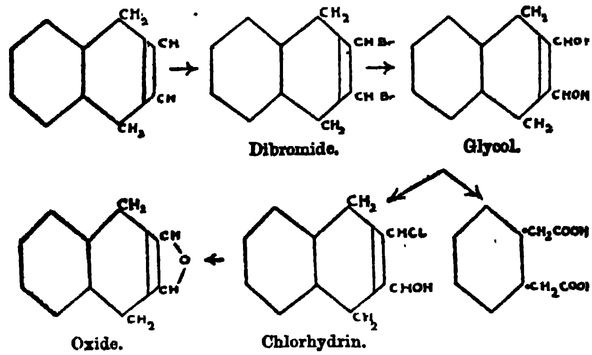
The latter is known as the CENTRIC FORMULA. In naming naphthalene derivatives the carbon atoms are numbered as shown:



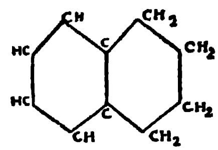
Other systems are in use: (1) The atoms numbered 1, 4, 5, 8 are often denoted by the letter α, and when it is desired to distinguish between them they are denoted respectively by α_1, α_2, α_3, α_4. The atoms numbered 2, 3, 6, 7 are often denoted by the letter β, and when it is desired to distinguish between them they are denoted respectively by β_1, β_2, β_3, β_4. (2) The atoms 1, 2, 3, 4 are numbered as above, but the atoms 8, 7, 6, 5 are numbered respectively 1^1, 2^1, 3^1, 4^1. On this system 1 : 8 dinitronaphthalene would be $1:1^1$ dinitronaphthalene. (3) The 1 : 8 di-derivatives are often called peri-derivatives; so also the 4 : 5, which are similarly situated to the 1 : 8. Peri-derivatives behave like ortho-derivatives, *i.e.* like 1 : 2 or 2 : 3 derivatives. A glance at the formula for naphthalene will show that mono-substitution products can exist in two forms, an α-form or a β-form. Thus if one hydrogen be replaced by a hydroxyl group we shall get one compound called α-naphthol if the hydroxyl group takes any of the positions 1, 4, 5, 8, for all these are similarly situated; and we shall get another compound called β-naphthol if the hydroxyl group takes any of the positions 2, 3, 6, 7, for all these are similarly situated. It will also be seen that ten di-derivatives are possible when the substituting group is the same—that is to say, there are ten dihydroxynaphthalenes; but there are fourteen if the substituting groups are different—there would be fourteen hydroxynaphthylamines, $C_{10}H_6OHNH_2$. In its chemical behaviour naphthalene bears considerable resemblance to benzene: it forms addition products with hydrogen, addition products and substitution products with chlorine and bromine; it can be nitrated and sulphonated like benzene. Homologues can be prepared by the methods of Fittig and Friedel and Crafts (*q.v.*) Its substitution products behave in general like those of benzene, but the substituents are more easily removed. The more important addition products and the halogen substitution products will be briefly described here, the remaining substitution products separately. Naphthalene can unite with two, four, six, eight, ten, or twelve hydrogen atoms, but only two of these need be mentioned. DIHYDRONAPHTHALENE—



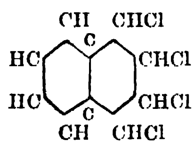
is a solid; melts at 15°; boils at 212°. It resembles ethylene in its chemical properties to a remarkable extent. Like ethylene it forms a dibromide by direct union with bromine, and the dibromide is hydrolysed by potassium carbonate to a substance like glycol-orthohydronaphthyleneglycol. The latter yields a chlorhydrin with hydrochloric acid, and the chlorhydrin with an alkali gives tetrahydronaphthyleneoxide corresponding to ethyleneoxide. The glycol on oxidation with chromic acid gives orthophneylenediacetic acid—



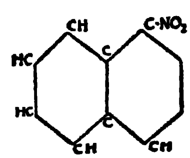
The dihydronaphthalene is obtained by reduction of a boiling solution of naphthalene in alcohol by sodium. TETRAHYDRONAPHTHALENE—



is an oil which turns brown in air; boils at 206°; is obtained by adding sodium to a solution of naphthalene in isoamyl alcohol. NAPHTHALENE TETRACHLORIDE—

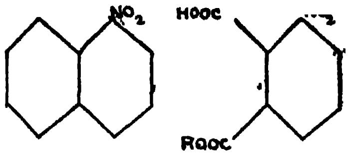


Crystallises in prisms, melts at 182°, and sublimes at 225°; soluble in benzene; when oxidised with strong nitric acid, it gives phthalic acid. It is obtained by passing chlorine into a chloroform solution of naphthalene, or by treating the latter with potassium chlorate and strong hydrochloric acid. α-CHLORNAPHTHALENE, $C_{10}H_7Cl$, is a liquid which boils at 263°. It is obtained by leading chlorine into boiling naphthalene, and by the action of phosphorus pentachloride on α-nitronaphthalene or on α-naphthalene sulphonic acid; also by the diazo-reaction from α-naphthylamine. β-CHLORNAPHTHALENE melts at 57°, and boils at 265°. It is obtained by the action of phosphorus pentachloride on the β-nitro and sulphonic acid derivatives, and by the diazo-reaction from β-naphthylamine. All the ten dichlornaphthalenes are known. NAPHTHALENE NITRO DERIVATIVES, α-NITRONAPHTHALENE—

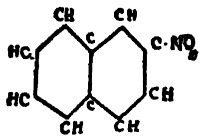


Crystallises in yellow needles; melts at 61°; boils at 304°. On reduction it yields α-naphthylamine. On

oxidation with chromic acid in acetic acid it yields vicinal nitro-phthalic acid

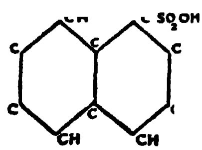


It is obtained by acting on naphthalene (5 parts) with a mixture of nitric acid (4 parts) and sulphuric acid (16 parts) at 40 to 50°, or by shaking naphthalene with nitric acid in the cold from time to time during three weeks, and crystallising the product from alcohol. β-NITRONAPHTHALENE—

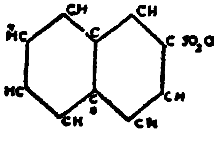


Crystallises in yellow needles; melts at 79°; is volatile in steam; readily soluble in alcohol. It is obtained by treating β-diazonaphthalene nitrite from β-naphthylamine, with precipitated cuprous oxide. 1 : 5 dinitronaphthalene; yellow needles; melts at 216°. To obtain it 100 grs. of naphthalene and 310 cc. of nitric acid are allowed to stand for twenty-four hours. Then 160 cc. of sulphuric acid are added, and the mixture heated on a water bath for a day. The acid is poured off, residue washed and dried and extracted with carbon disulphide, then repeatedly extracted with acetone to separate 1 : 8 dinitronaphthalene. It is now crystallised from xylene. For its use *see* NAPHTHYLAMINES *and* NAPHTHAQUINONES.

Naphthalene Sulphonic Acids (*Chem.*) α-naphthalene sulphonic acid—

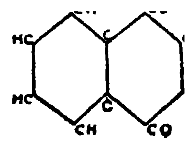


A crystalline deliquescent solid; melts at 85 to 90°. Heated with sulphuric acid, it is transformed to naphthalene-β-sulphonic acid; heated with hydrochloric acid at 200°, it is resolved into naphthalene and sulphuric acid. On fusion with caustic soda it yields α-naphthol; its sodium salt with phosphorus pentachloride gives the chloride $C_{10}H_7SO_2Cl$ (MP66°). It is prepared by heating naphthalene with its own weight of sulphuric acid at 90° for about three hours. The product is poured into water, separated from unchanged naphthalene, neutralised with chalk, filtered and concentrated, when calcium naphthalene-β-sulphonate separates. The mother liquor gives the calcium salt of the α-acid on further concentration. The acid is set free by addition of sulphuric acid. β-Naphthalene sulphonic acid—



Crystallises in plates; not deliquescent; melts about 101°; not decomposed at 200° by hydrochloric acid. Its sodium salt with phosphorus pentachloride gives the acid chloride $C_{10}H_7SO_2Cl$ (M P76°); fused with caustic soda it gives β-naphthol. It is prepared by heating naphthalene with its own weight of sulphuric acid at 180° for six hours; the product is poured into water, and on adding salt the sodium salt separates. The free acid can be obtained by making the calcium salt instead of the sodium salt and decomposing it by sulphuric acid. The acid can be hydrolysed by distilling in superheated steam with dilute sulphuric acid at 135°. When the sodium salt of this acid is further sulphonated, it yields the 1 : 6 disulphonic acid. The 1 : 5 disulphonic acid is obtained from naphthalene (1 part) and fuming sulphuric acid containing 30 per cent., SO_3 (4 parts), at a low temperature. The 2 : 6 disulphonic acid is obtained from naphthalene and sulphuric acid (1 to 5) at 180° for twenty-four hours. The disulphonic acids, which cannot be obtained by direct sulphonation, are obtained from the naphthylamine sulphonic acids. These acids are largely used in the preparation of other naphthalene derivatives. For instance, when the α-acid is nitrated and then reduced, a mixture of 1 : 8-α-naphthylamine sulphonic acid and the 1 : 5 acid is obtained, and these can be separated by means of their sodium salts, the salt of the former being much less soluble in water than that of the latter.

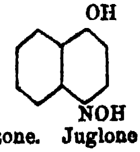
Naphthaquinones (*Chem.*) α-Naphthaquinone—



A yellow crystalline solid; melts at 125°, but begins to sublime below 100°; characteristic quinone smell; readily soluble in alcohol, ether, benzene; distils in steam. It is prepared by oxidising a solution of naphthalene in glacial acetic acid by chromic acid in 80 per cent. acetic acid. The mixture is left for three days, during which it is shaken from time to time; the naphthaquinone separates on addition of water, and is crystallised from petroleum ether. It is also obtained by oxidation of α-naphthylamine by potassium dichromate and dilute sulphuric acid in the cold. On reduction with zinc and hydrochloric acid it gives 1 . 4 dihydroxynaphthalene; on oxidation with nitric acid it gives phthalic acid; forms addition products with one molecular proportion of bromine or chlorine, which readily lose halogen acid:

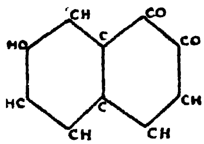
$$C_6H_4\left\langle\begin{array}{l}CO-CH\\ \quad\;\;\;\|\\ CO-CH\end{array}\right. \rightarrow C_6H_4\left\langle\begin{array}{l}CO-CHBr\\ \quad\;\;\;|\\ CO-CHBr\end{array}\right. \rightarrow C_6H_4\left\langle\begin{array}{l}CO-CBr\\ \quad\;\;\;\|\\ CO-CH\end{array}\right. .$$

With primary amines substitution products are formed on heating, *e.g.* with aniline 2-anilido-α-naphthaquinone, $C_{10}H_5O_2NHC_6H_5$, which is red; with hydroxylamine it forms α-nitroso-α-naphthol,



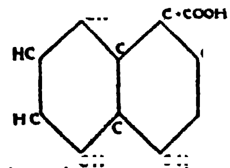
with phenylhydrazine it gives a hydrazone. Juglone

(*q.v.*) is 5-hydroxy-α-naphthaquinone. Naphthazarin is 5 : 6-dihydroxy-α-naphthaquinone. It is a lustrous brown crystalline (needles) solid, which sublimes on heating; soluble in alcohol and glacial acetic acid; dissolves in strong sulphuric acid with a red colour, and in alkalis with a blue colour. Its sodium bisulphite compound is used as a black dye, Alizarine Black. It is prepared by heating 1 : 5 dinitronaphthalene with concentrated sulphuric acid, and adding zinc from time to time; then the product is diluted with water and filtered. The naphthazarine, which separates on cooling, is purified by solution in alkali and precipitation with acid. It is also prepared by electrolysing the mixture of 1 : 8 and 1 : 5 dinitronaphthalenes obtained on direct nitration of the hydrocarbon in strong sulphuric acid at 130°, pouring the product into water at 0°, filtering, and boiling for an hour (D.R.P. 79,406). β-naphthaquinone,



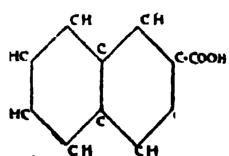
Red needles; decomposes at 115 to 120°; no smell; not volatile in steam; soluble in alcohol, ether, acetic acid, benzene. It is prepared by oxidising a solution of α-amido-β-naphthol hydrochloride in solution in water containing some sulphurous acid by means of ferric chloride solution; the quinone separates, and it is washed and dried. The α-amido-β-naphthol is obtained from β-naphthol by action of nitrous acid, which gives α-nitroso-β-naphthol, and the latter on reduction with ammonium sulphide gives α-amido-β-naphthol. Many of its reactions are similar to those of α-naphthaquinone; *e.g.* on reduction it gives 1 : 2 dihydroxynaphthalene: on oxidation it gives phthalic acid; it adds bromine and chlorine in the same way; behaves in the same way towards hydroxylamine and phenylhydrazine.

Naphthoic Acids (*Chem.*) These are the naphthalene analogues of benzoic acid. α-Naphthoic Acid crystallises in white needles; melts at 162°; sparingly soluble in water; soluble in alcohol; heated with soda lime, it gives naphthalene; on nitration it yields a mixture of the 1 : 5 and 1 : 8 nitro-α-naphthoic acids; on oxidation with chromic acid in glacial acetic acid, it gives phthalic acid. It is obtained by hydrolysis of its nitrile, and the latter can be obtained by distilling sodium naphthalene-α-sulphonate with potassium cyanide or ferrocyanide. It is also obtained fusing potassium naphthalene - α - sulphonate with sodium formate.

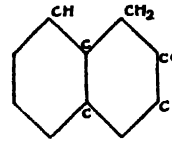


α-naphthoic acid

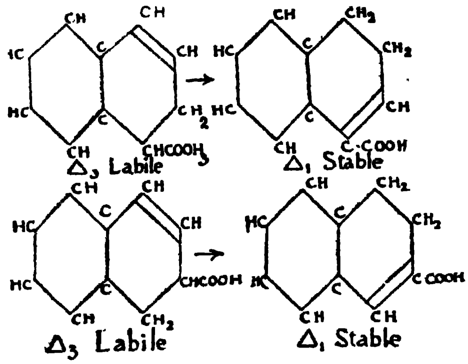
β-Naphthoic Acid: white needles; melts at 185°; sparingly soluble in water; very soluble in alcohol; reactions with soda lime and chromic acid are the same as the α-acid; on nitration it yields five nitro-β-naphthoic acids. It is obtained by hydrolysis of its nitrile, and the latter is formed from the sodium β-sulphonate just as with the α-acid. Both acids yield hydroxy-acids, which are analogous to the hydroxy-benzoic acids. These hydroxy-acids can be obtained by heating the sodium salt of the two naphthols in carbon dioxide, just as salicylic acid is obtained from the sodium salt of phenol. From the sodium salt of β-naphthol treated with carbon dioxide at 120° to 145°, the carboxyl group enters at position 1; but at 200° to 250° the carboxyl group enters at position 3. This last acid has a yellow colour, and on this account this formula has been suggested for it:



β naphthoic acid

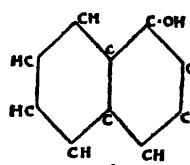


The acids (OH – 1 : COOH – 2) : (OH – 2 : COOH – 1) : (OH – 2 : COOH – 3) all colour ferric chloride solution blue. Both naphthoic acids on reduction with sodium amalgam give dihydronaphthoic acids, the hydrogen entering the substituted ring. When the reduction is effected in the cold, labile forms are obtained which pass on warming with caustic soda partly into more stable forms:



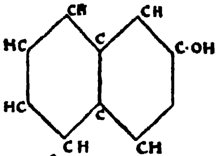
Naphthol Black. *See* Dyes and Dyeing.

Naphthols. α-Naphthol: white shining needles; melts at 94°; boils at 279°; smells like phenol; readily soluble in alcohol, ether, benzene; sparingly soluble in water; volatile in steam. It can be obtained by the diazo-reaction from α-naphthylamine, but is obtained on the large scale by heating sodium naphthalene - α - sulphonate with caustic soda, acidifying the product and distilling. Its synthesis is given under naphthalene. With caustic soda the hydroxyl hydrogen is replaced by sodium, giving sodium naphtholate; with ferric chloride it gives a violet precipitate of dinaphthol; yields a nitroso-compound (*q.v.*) with nitrous acid; on reduction with sodium and amyl alcohol it forms ar-tetrahydro-α-naphthol (*see under* Naphthylamines), which melts at 69°. On nitration it gives the dinitro-α-naphthol, OH1 : 2 : 4, which resembles picric acid. The sodium salt is the yellow dye Martius yellow, also called naphthol yellow.



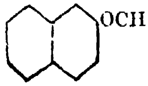
α naphthol

β-NAPHTHOL: white shining scales; melts at 122°; boils at 286°; smells like phenol; readily soluble in alcohol, ether, benzene, hot water; soluble in olive oil (1 in 8); powerful antiseptic, and is on this account used in medicine. Obtained like α-naphthol, using β-naphthylamine or sodium naphthalene-β-sulphonate. Reacts

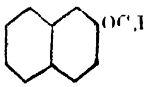


β naphthol

with caustic soda like α-naphthol; also with ferric chloride, but the coloration is green: also with nitrous acid; on reduction with sodium and amyl alcohol it yields ac- and ar-tetrahydro-β-naphthol; the former boils at 264°, and the latter melts at 58° and boils at 275°. Both naphthols form ethers. The β-naphthol methyl and ethyl ethers—



M.P. 70°, B.P. 274°, and



M.P. 37°, B.P. 274,

are obtained by heating β-naphthol with methyl and ethyl alcohol, as the case may be, and concentrated sulphuric acid at 125°. They are both used in making perfumes: the former smells like neroli oil (the oil from flowers of the bitter and sweet orange); the latter, also known as Bromelia, has an acacia-like smell. Both naphthols combine with diazo-compounds: α-naphthol takes on the diazo-compound at position 4, or, if this is occupied, at position 2, while β-naphthol takes it on at position 1, or, if this is occupied, at position 3. Many of these azo-compounds are dyes. Examples: *see* FAST RED (ROCELLINE) *and* FAST BROWN *under* NAPHTHYLAMINES: here the diazo-compound is that of naphthionic acid. BIEBRICH SCARLET is obtained from β-naphthol and amidoazobenzene disulphonic acid; it is

$$NaOO_2SC_6H_4 . N = N . C_6H_3\begin{cases} SO_2ONa \\ N \end{cases}$$

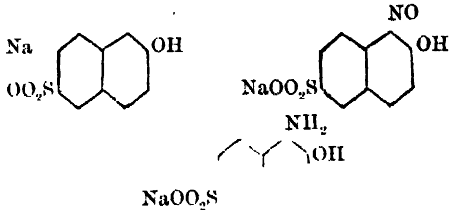
Both naphthols yield a large number of sulphonic acids, which are used in making dyes. α-naphthol-sulphonic acid, NW (1 : 4), is obtained by diazotising naphthionic acid and boiling with dilute sulphuric acid, or by heating sodium naphthionate with a solution of caustic soda under pressure: white crystals; melts at 170°; soluble in water. ORSEILLINE (BB) is an example of a red dye obtained from this acid by treating with diazotised amidoazotoluene-monosulphonic acid; it has the formula

$$\begin{matrix} CH_3 \\ NaO . O_2S \end{matrix}\Big\rangle C_6H_3 . N_2 . C_6H_3(CH_3)—N_2—C_{10}H_5\Big\langle\begin{matrix} {}^1OH \\ {}_4SO_2ONa \end{matrix}$$

β-naphthol sulphonic acid (2.6) is obtained by heating β-naphthol with twice its weight of concentrated sulphuric acid at 100°; on adding water and salting out its sodium salt crystallises. This acid is used in making the dye BRILLIANT ORANGE (Ponceau 4 GB) by allowing it to act on diazotised aniline. The dye has the formula

$$C_6H_5—N : N—\overset{1}{C_{10}}H_5\overset{2}{O}H . SO_2^6ONa.$$

The photographic developer EIKONOGEN is prepared from this acid by acting on one of its salts with sodium nitrite and hydrochloric acid, and reducing the nitroso-compound thus formed by stannous chloride:



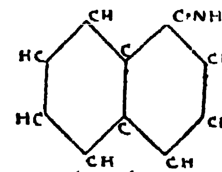
Eikonogen.

It can also be obtained by reducing the above dye (Ponceau 4 GB) by stannous chloride. Nine of the ten theoretically possible dioxynaphthalenes are known. Several trioxynaphthalenes are known. The 1 : 4 : 5 compound is α-hydrojuglone. *See* JUGLONE *and* NAPHTHAQUINONES.

Naphthol Yellow. *See* DYES AND DYEING.

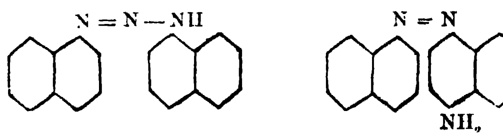
Naphthyl (*Chem.*) The name given to the residue remaining when one hydrogen atom is removed from the naphthalene molecule. The residue when a hydrogen atom is removed from an α-position is called α-naphthyl; when it is removed from a β-position it is called β-naphthyl. *See* NAPHTHYLAMINES.

Naphthylamines. α-NAPHTHYLAMINE: white solid; crystallises in flat needles; melts at 50°; boils at 300°; turns red in air; unpleasant smell; easily volatile; insoluble in water; readily soluble in alcohol, ether, aniline. It is obtained by reducing α-nitronaphthalene with tin and hydrochloric acid, or, on the large scale, with iron in place of tin. It is a base, and



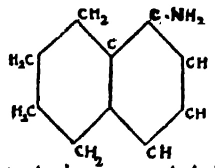
α-naphthylamine

forms salts with acids; solutions of its salts give a blue precipitate with oxidising agents, *e.g.* with chromic acid. Its salts give the diazo-reaction with nitrous acid, and diazo-naphthalene-sulphate gives α-naphthol on boiling with dilute acid. The diazo-chloride, treated with α-naphthylamine hydrochloride in the cold and alkaline solution, gives diazoamidonaphthalene, which undergoes intramolecular change to α-AMIDO-AZONAPHTHALENE—



The latter compound, on heating with α-napthylamine hydrochloride in glacial acetic acid solution, gives the dye Magdala red or naphthalene red. Its alcohol solution has splendid yellow fluorescence. A solution of α-naphthylamine in dilute acetic acid, when mixed with a solution of sulphanilic acid, constitutes an extremely delicate test for nitrous acid or a nitrite (1 in 100,000,000). This depends on a similar reaction to the above, α-naphthylamine-azobenzene sulphonic acid being formed, $C_6H_4SO_2OH . N_2C_{10}H_6NH_2$, which gives a beautiful red colour in

acid solution. On reduction of α-naphthylamine with sodium in boiling amyl alcohol, four hydrogen atoms are added on to the unsubstituted nucleus, forming ar-TETRAHYDRO-α-NAPHTHYLAMINE (ar- is an abbreviation of aromatic, and may be taken to mean that the substituted ring acquires a true aromatic character); a liquid; boils at 275°; a weak base; reduces salts of the noble metals; gives diazo-reaction with nitrous acid; on oxidation it

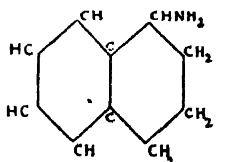


ar-tetrahydro-α-naphthylamine

gives adipic acid,

$$\begin{array}{l} CH_2.COOH \\ H_2C \\ \quad | \\ H_2C \\ CH_2.COOH \end{array}$$

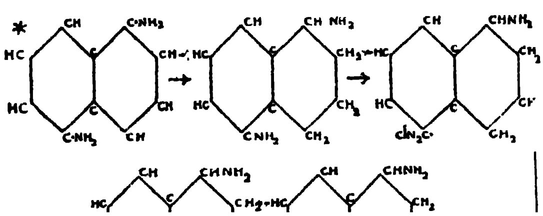
, and oxalic acid. The isomeric ac-TETRAHYDRO-α-NAPHTHYLAMINE (ac- is an abbreviation of alicyclic, and may be taken to mean that the substituted ring acquires the properties of an aliphatic (*q.v.*) substance) is a liquid; boils at 246°; has a smell like piperidine; strong base, taking up carbon dioxide from the air; no reducing properties; with nitrous acid gives crystalline nitrate; on oxidation with potassium permanganate it gives ORTHOCARBOXY-β-PHENYL-PROPIONIC ACID,



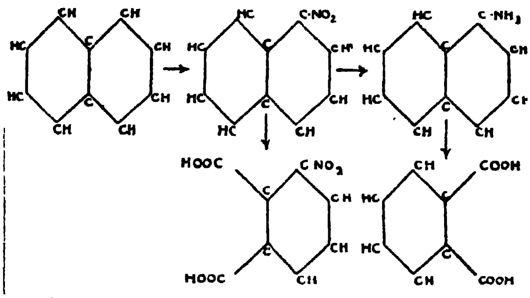
ac-tetrahydro-α-naphthylamine

$$\begin{array}{l} CH \\ HC \quad\; \diagup COOH \\ \quad\;\; | \\ HC \quad\; \diagdown CH_2.CH_2.COOH \\ CH \end{array}$$

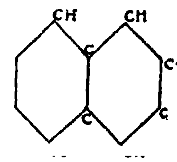
It is obtained from 1:5 naphthylenediamine by reducing with sodium in amyl alcohol, diazotising, reducing to the hydrazine, and warming with copper sulphate solution. The 1:5 diamine is obtained from 1:5 DINITRONAPHTHALENE—



See NITRONAPHTHALENES. When α-naphthylamine is oxidised with potassium dichromate and dilute sulphuric acid it gives phthalic acid and 1:4 napthaquinone, and the latter on further oxidation also gives phthalic acid. As α-nitronaphthalene, from which α-naphthylamine is obtained on reduction, gives nitrophthalic acid, naphthalene must contain two benzene rings, one of which is destroyed when the nitro-compound is oxidised, and the other when the amine is oxidised—



β-NAPHTHYLAMINE: white crystalline scales: melts at 112°; boils at 294°: no smell; soluble in water (solution has blue fluorescence), alcohol, ether; volatile in steam. Obtained by heating β-naphthol with the zinc chloride compound of ammonia ($ZnCl_2.NH_3$) at a high temperature. It is a base; does not give a colour with oxidising agents. Its salts give the diazo-reaction with nitrous acid. On reduction with sodium in boiling amyl alcohol solution, it yields both the ar- and ac-tetrahydro-β-naphthylamines, the latter in larger amount (96 per cent.); they closely resemble the corresponding α-compounds, and boil respectively at 276° and 249°. A very large number of substitution products of the two naphthylamines is known, especially nitro-derivatives and sulphonic acids; they are extensively used in dye making.



β-Naphthylamine

NAPHTHIONIC ACID—

$$\begin{array}{ccc} & CH \quad C.NH_2 & \\ HC & & CH \\ HC & & CH \\ & CH \quad C.SO_2OH & \end{array}$$

a white solid (needles); sparingly soluble in water; obtained by heating α-naphthylamine with concentrated sulphuric acid (4 to 5 parts) at 100 to 110°; is used in the preparation of CONGO RED (*q.v.*), and many other red dyes, *e.g.* FAST RED (rocelline)—

1 2

$_4 \diagdown SO_2ONa$

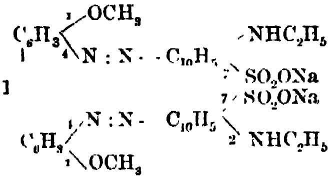
from naphthionic acid and β-naphthol, FAST BROWN N. from naphthionic acid and α-naphthol. When β-naphthylamine is treated with strong sulphuric acid, four different sulphonic acids are obtained, *viz.*

2 : 8 (α-acid), 2 : 6 (β-acid), 2 : 5 (γ-acid), 2 . 7 (δ-acid).

The α- and γ-acids are formed first, and the other two are formed from these at a higher temperature; the β- and δ-acids are important in dye making, and

* This compound, ac-ar-tetrahydronaphthylenediamine, behaves at the same time as an aromatic and an alicyclic amine.

they are more conveniently obtained from the corresponding β-naphthol sulphonic acids by heating with ammonia under pressure. The cotton dye HELIOTROPE may be taken as an example of a dye from the δ-acid: it is obtained from the diazo-compound of dianisidine, and has the formula



Napier's Compasses. Drawing compasses, with legs made to fold up for carrying in the pocket.

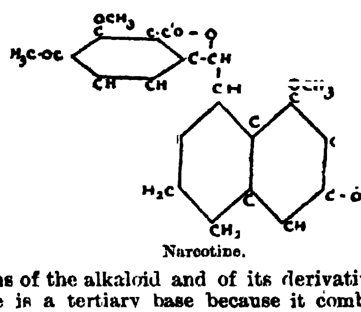
Napkin Pattern. *See* LINEN FOLD.

Naples Yellow (*Dec.*) Most of the yellow sold under this name is a mixture of cadmium yellow with zinc white. True Naples yellow is prepared from oxide of lead and antimony. It is not much used now, having been largely replaced by chrome yellow.

Napping (*Textile Manufac.*) Process of developing the nap by rubbing the raised fibres into small curls, the work being done on the napper or napping machine.

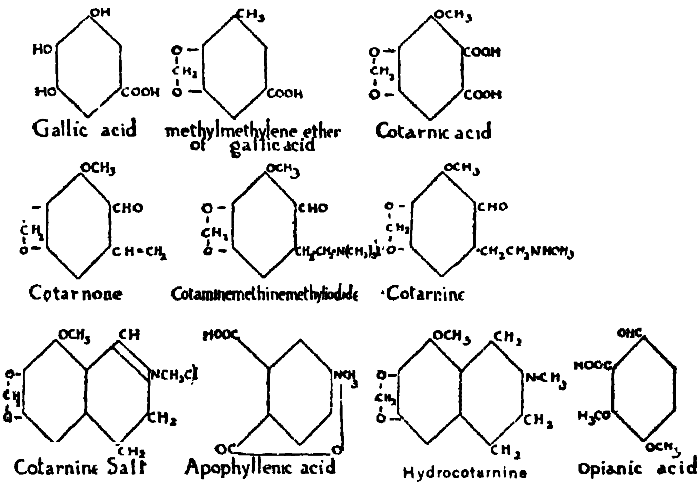
Narcotic. A drug used to produce sleep or deaden pain. Most narcotics are poisonous when taken in large doses.

Narcotine. White needles; melts at 176°; nearly insoluble in water; sparingly soluble in cold alcohol; fairly soluble in boiling alcohol; fairly soluble in benzene; easily soluble in chloroform; strongly lævo-rotatory, but its salts are dextrorotatory; only feebly poisonous, and it has no narcotic action (hence it is sometimes called anarcotine); it is a feeble base, having no action on litmus, its salts being hydrolysed by water, and sodium acetate liberates the base from a solution of narcotine hydrochloride. It was the first alkaloid extracted from opium, and is the principal alkaloid in Indian opium. The amount in opium is from about 1 to 9 per cent., and it is nearly all uncombined, so that when opium is extracted with water nearly all the narcotine remains in the residue. This residue is extracted with dilute hydrochloric acid, the solution precipitated with sodium acetate, and the precipitate extracted with boiling alcohol; the alkaloid crystallises out on cooling. The above formula for narcotine is based on the following re-



Narcotine.

actions of the alkaloid and of its derivatives. Narcotine is a tertiary base because it combines with methyl iodide. It contains three methoxy-groups, because one molecular proportion of the alkaloid on treatment with hydriodic acid yields three molecular proportions of methyl iodide. Further: (1) it is hydrolysed by dilute sulphuric acid, giving opianic acid and hydrocotarnine. But these two do not yield narcotine when made to unite by warming with concentrated hydrochloric acid: an isomeric compound isonarcotine is the product. (2) It is reduced by zinc and dilute sulphuric acid to meconine and hydrocotarnine. (3) It is oxidised by manganese dioxide and sulphuric acid, or by nitric acid to opianic acid and cotarnine. (4) Meconine and hydrocotarnine are respectively reduction products of opianic acid and cotarnine. The constitution of meconine and of opianic acid is known. Cotarnine is an aldehyde; it is also a secondary base uniting with methyl iodide to form cotarninemethinemethyl iodide. This last compound is resolved by caustic soda into trimethylamine and cotarnone, and the latter on oxidation yields cotarnic acid. Cotarnine itself, on oxidation, yields cotarnic acid, and another acid of known constitution—the methyl betaine of cinchomeronic acid (apophyllenic acid). The constitution of cotarnic acid is deduced from the facts that it forms an anhydride, and yields on heating with hydrochloric acid the methylmethylene ether of gallic acid, and with hydriodic acid gallic acid itself. Thus we have:



Narrow (*Typog.*) The name applied to furniture (*q.v.*) three picas in width.

Narrow Gauge (*Civil Eng.*) A term now commonly applied in England to any railway track of gauge less than the standard gauge of 4 ft. 8½ in. A 3 ft. gauge is the commonest narrow gauge in England. It was formerly used to distinguish the present standard gauge from the wide gauge (*q.v.*), which is now obsolete.

Narthex (*Architect.*) An inner porch in Early Christian churches, used for the reception of penitents and the repetition of catechisms. It is separated from the nave by means of a screen. *See* BASILICA, NAVE.

Narwhal (*Zool.*) A cetaceous mammal (*Monodon monoceros*) belonging to the Dolphin tribe, frequenting Arctic seas. Its curious twisted tusk, often measuring eight feet in length, yields a very valuable ivory. The oil also is used in commerce.

Nasturtium (*Botany*). The watercress (*Nasturtium officinale*) is a member of the Dicotyledon order *Cruciferæ*. The garden nasturtium is a *Tropæolum* belonging to the *Tropæolaceæ*.

National Gallery (London). The present building on the north side of Trafalgar Square, erected from designs by Mr. Wilkins, was opened in 1838. The Gallery was founded in 1824 by the purchase of Mr. J. J. Angerstein's collection, numbering thirty-eight pictures, which were exhibited in Pall Mall. The Gallery contains most important examples of the English school, including masterpieces by Reynolds, Gainsborough, Landseer, Hogarth, Turner, Constable, Wilkie, Romney, Etty, Herring, Callcott, Mulready, Maclise, as well as many of the finest examples of Raphael, Titian, Corregio, Vandyck, Rembrandt, Rubens, Teniers, Cuyp, Murillo, Velasquez, Claude, and others. Admission to the public free on Mondays, Tuesdays, Wednesdays, and Saturdays; a charge of sixpence is made on Thursdays and Fridays (students' days).

National Gallery of British Art (Tate Gallery). This gallery, erected by the generosity of Sir Henry Tate, Bart., is situate at Millbank, S.W., facing the Thames. Many of the works of British artists have been transferred to this building from the National Gallery. Students' days, Tuesdays and Wednesdays. A charge of sixpence is made for admission on these days; on other weekdays admission is free.

National Portrait Gallery (London). This gallery is situate in St. Martin's Place (at the rear of the National Gallery). It was built by the generosity of Mr. W. H. Alexander, and was opened to the public in 1896. Previously the portraits were at South Kensington. The collection numbers about 1,400. Admission as to National Gallery.

Native. The term applied to metals which are found in the earth in the condition of elements. *See* METALLURGY *and* MINING.

Natrolite (*Min.*) A hydrous sodium aluminium silicate, $Na_2O \cdot Al_2O_3 \cdot 3SiO_2 \cdot 2H_2O$. Orthorhombic. One of the zeolites. It occurs in slender crystals, usually colourless, sometimes yellowish; also massive and radiating. It fuses in the candle flame. Also known as mesotype. From cavities in basic volcanic rocks in Scotland, Ireland, the United States, etc.

Natron (*Min.*) Sodium carbonate, $Na_2CO_3 \cdot 10H_2O$ Soda = 18·8, carbon dioxide = 26·7, water = 54·5 per cent. Monosymmetric, usually as an incrustration. It effervesces with acids, and effloresces on exposure. It occurs in association with other carbonates of sodium in Egypt, Hungary, and Mexico.

Natural (*Music*). Marked by a ♮. It has the power of restoring a note to its original position after being made sharp or flat. Naturals always fall on the white keys of the pianoforte, hence the scale of C is sometimes spoken of as the natural scale. When a natural occurs with a sharp or flat, as ♮♯, or ♮♭, it restores respectively a double sharp to a sharp, or a double flat to a flat.

—— *or* **Naperian Logarithms.** *See* LOGARITHMS.

Natural Draught (*Eng.*) Draught or air supply produced by the uprush of heated gases in flues and chimneys. *See also* FORCED DRAUGHT.

Natural Gas. Gaseous compounds of carbon and hydrogen which are given forth from the earth under various geographical conditions. They include the gaseous exhalations from swamps, the various gases given off by active or by dormant volcanoes, and the gaseous compounds arising from bore holes that have penetrated to the underground reservoirs where petroleum is found. The gas is principally Methane, but is accompanied by Hydrogen, Ethane, Propane, and Butane.

Natural Magnet. *See* MAGNET.

Natural Period (*Phys.*) The time occupied by some cycle of operations, movements, etc., when the body (or system of bodies) under consideration is left to itself.

Natural Scale (*Surveying*). A scale so named as to indicate the ratio a distance, as represented on a map, bears to the actual distance; *e.g.* one inch to a mile is represented by the natural scale $\frac{1}{63360}$.

Natural Waters (*Chem.*) These are rain, river, spring, and sea water. *See* WATER.

Naumachia (*Archæol.*) A large building in the form of an amphitheatre, used by the Romans for giving representations of sea fights.

Naumann's Notation (*Min.*) One of the systems of expressing the relation of a crystal form to the axis. In it the components of the symbol express the relations of the intercepts of the crystal form on the three axes, the unit length of the axis being designated by O in the cubic system and P in the other systems, while ∞ is used when the intercept is infinity, *i.e.* when the form is parallel to that particular axis.

Naut *or* **Knot.** *See* NAUTICAL MILE.

Nautical Almanack (*Astron., Navigation*). An elaborate series of data showing the motions and positions of the celestial bodies. It is compiled at the Nautical Almanack Office in London, for four years in advance, and furnishes data which are absolutely indispensable in navigation and exploration, and of the utmost importance to all astronomical observers. It is perhaps the finest example in existence of the utility of what are apparently the most abstruse and theoretical observations and calculations.

Nautical Mile. A minute of arc of the Meridian; sometimes called a knot, though the latter is, correctly speaking, the rate of one nautical mile per hour. A nautical mile is 6,087 ft., or 1·152 miles. *See also* WEIGHTS AND MEASURES.

Naval Crown (*Her.*) A circlet on which is arranged alternately four sterns and four masts with sail.

Nave. The central part of a wheel; also called HUB and BOSS.

—— (*Architect.*) The part of a church situate between the aisles and west of the chancel. The term nave is derived from the Greek word *Naos*. *See* CELL, AISLE, *and* CHANCEL.

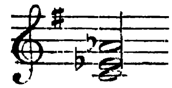
Navier's Formula (*Eng., etc.*) *See* GORDON'S FORMULA.

Nb (*Chem.*) The symbol for NIOBIUM (*q.v.*)

Ne (*Chem.*) The symbol for NEON (*q.v.*)

Neapolitan Sixth (*Music*). The major common chord of the minor second of the key in its first inversion—a chord on the subdominant with the

minor 3rd and minor 6th added. In the key of G the Neapolitan 6th is



Neap Tides (*Astron.*) *See* TIDES *and* LAGGING.

Neat (*Plastering*). Cement or plaster without the addition of sand, *i.e.* a mixture of cement or plaster with water only.

Neat's Foot Oil. *See* WASTE PRODUCTS.

Neat Soap (*Soap Manufac.*) *See* FITTING.

Nebeculæ (*Astron.*) *See* MAGELLANIC CLOUDS.

Nebris (*Art*). A fawn's skin, the covering of Bacchus, Bacchantes, and fauns.

Nebula (*Astron.*) A luminous cloud seen in the heavens on a dark night, which no telescopic power can resolve into stars. The form is both regular and irregular. That in Orion is the most brilliant and easy to see.

Nebular Hypothesis (*Astron.*) A hypothesis first worked out in mathematical detail by Laplace. The basis of it is that at some time in the past the matter which is now gathered into the form of the sun and planets was once a large nebula in an incandescent state. This subsequent cooling and rotating mass contracted and left behind masses which form the planets.

Nebule (*Architect.*) An enriched moulding used in Norman work. The lower edge of the moulding is an undulating line, in the hollows of which spheroidal forms are worked.

Nebuly *or* **Nebulée** (*Her.*) A partition line. Similar to dovetail joint, only instead of being angular it bends in curves.

Neck (*Architect.*) That part of a capital immediately above its lowest mouldings, usually a continuation of the shaft; *e.g.* that part of a Roman Doric capital between the astragal and the annulets. *See* COLUMN.

—— (*Eng.*) A general name for a narrow portion of some object; in particular, the JOURNAL (*q.v.*) of a shaft.

Necklace. An ornament worn round the neck; probably the most universal and the oldest form of personal adornment.

Necks, Volcanic (*Geol.*) A general term for the materials which have finally occupied the pipe or chimney of a volcano between the crater and the focus. In many cases the vent is occupied by fragmentary material or agglomerate, which has been ejected from the volcano during an explosive eruption, and which has subsequently fallen back into the vent and finally choked it up. In other cases the vent has been filled with what was originally fluid rock, which has consolidated there and been left as a plug; or there may exist a combination of these two. Necks commonly give rise to conspicuous scenic features.

Necropolis. A large cemetery; in ancient times the burial places were frequently subterranean. *See* CATACOMBS.

Needle (*Carp.*) In shoring, the needle is the horizontal timber going through the wall and resting on the top of dead shores or the head of raking shores. *See* SHORING.

Needle (*Elect.*) *See* MAGNETIC NEEDLE.

—— (*Mining*). A rod used in making a small hole for firing a blasting charge.

——, **Astatic** (*Elect.*) *See* ASTATIC NEEDLES.

——, **Dipping** (*Elect.*) A magnetic needle turning about a horizontal axis; used in measuring the DIP (*q.v.*)

Needle Lubricator (*Eng.*) An oil vessel with a vertical passage or tube leading from the lowest part of the oil space to the point where lubrication is required. A thin rod loosely fitting this passage prevents a too rapid flow of oil, but its vibration causes a small regular stream to run down into the bearing.

Needle Machine (*Lace Manufac.*) That form of Swiss embroidery machine, also known as the hand machine, wherein small needles with an eye in the middle, threaded with a suitable length of silk or thread, are mechanically passed back and forth through the fabric to be embroidered, with the same results as in hand work. It is a much slower process (about six stitches a minute) than shuttle embroidery, but the results attained justify the extra labour.

Needle Valve (*Eng.*) A valve consisting of a pointed rod of metal; the point just fits into a suitably shaped hole, which it opens or closes by its motion. Needle valves are commonly used in SPRAY CARBURETTERS (*q.v.*)

Negative (*Photo.*) A photographic image or picture in which the lightest portions of the object are represented by the darkest portions of the image, and *vice versâ*. A negative is formed by the action of the light on a sensitive film, which is supported on a plate of glass or a sheet of paper or celluloid.

—— (*Textile Manufac.*) A term applied to any shedding or taking up motion requiring the assistance of springs or weights. Sometimes termed non-positive. Also applied to different working parts of spinning machinery.

Negative Brush (*Elect.*) The brush of a dynamo or motor, which is connected to the negative terminal.

Negative Charge (*Elect.*) A charge of electricity of the kind produced on a rod of resin by rubbing it with flannel.

Negative Crystal (*Phys.*) A Uniaxal Crystal (*q.v.*) in which the velocity of the Extraordinary Ray is in general greater than that of the Ordinary Ray. *See also* DOUBLE REFRACTION.

Negative Plate of a Cell (*Elect.*) In a primary cell, the zinc plate (or corresponding element); in a storage cell or accumulator, the plate which is connected to the negative terminal of the charging dynamo.

Negative Stress (*Eng., etc.*) A TENSION or TENSILE STRESS.

Negur (*Soap Manufac.*) The dirty aqueous layer which settles in the soap pan in the manufacture of fitted soaps (*q.v.*) Also spelled negre, nigre, and nigger. *See* FITTING.

Neodymium (*Chem.*) *See* DIDYMIUM.

Neon (*Chem.*), Ne. Atomic weight, 20. A gas occurring in air (1 to 2 parts in 100,000); has no reactions; the ratio of the two specific heats is 1:66, so that it has a monatomic molecule, and is therefore an element. Has a characteristic and complex spectrum—many lines in the red, three in the green, and a number of blue lines. Density, 9·97. Critical temperature below −205°. To obtain it the uncondensed gases from an air liquefier, consisting of helium, neon, nitrogen, argon, etc., are liquefied and air blown through the liquid. The first portions of gas which come away are collected separately, and the oxygen and nitrogen removed respectively by red-hot copper and heated magnesium. The remaining gas is liquefied, and on distillation helium and neon pass over, and these can be separated by fractional distillation at the temperature of boiling hydrogen: at this temperature helium is gaseous, while neon is liquid or possibly solid.

Nep (*Textile Manufac.*) Small cluster of fibres in the wool staple. Difficult to open or separate. It is such fibres that form NOIL (*q.v.*) in the combing process. *See also* NEPS.

Nepheline (*Min.*) A silicate of aluminium, sodium, and potassium, $3Na_2O.K_2O.4Al_2O_3.9SiO_2$. Silica = 44·2, alumina = 33·7, soda = 16·9, potash = 5·2 per cent. Hexagonal; usually in short prisms. It occurs in several kinds of eruptive rocks. One of the best known localities is Monte Somma.

Nephelium (*Botany*). A genus of the order *Sapindaceæ*, native to Malayasia. It is important on account of its fruits, the Rambutan, Longan, and Litchi.

Nephrite (*Min.*) A synonym for jade (*q.v.*)

Neps (*Cotton Manufac.*) Damaged or broken fibres which have escaped the action of the carder and appear as specks on the doffer web.

Neptune, Planet (*Astron.*) Distance from sun, 2,791,000,000 miles; mean diameter, 34,800 miles; periodic time, nearly 165 years. Possesses one satellite. This planet was discovered by Le Verrier and Adams from purely theoretical calculations, which predicted its existence on account of certain perturbations (*q.v.*) which were produced in the motion of Uranus by some unknown body.

Nernst Lamp. *See* ELECTRIC LIGHTING.

Neroli, Oil of (*Botany*). An oil obtained by distillation of the flowers of *Citrus aurantium*, var. *Bigaradia*. It is extensively used in perfumery.

Nervures (*Architect.*) The ribs bounding the sides of a vaulted compartment.

Nessler's Reagent (*Chem.*) A solution of mercuric chloride (17 grams in 300 cc. water) is added to a solution of potassium iodide (35 grams in 100 cc. water) till a permanent precipitate is obtained; then a 20 per cent. solution of caustic soda is added to make up to a litre. A little more of the mercuric chloride is now added to cause a slight precipitate. The clear liquid is Nessler's reagent. It is used as a test for ammonia: delicacy, about 1 part ammonia in 25,000,000 parts water. For action *see* MERCURY COMPOUNDS.

Nest (*Glass Manufac.*) A cushion upon which sheets of glass are placed for splitting with the diamond.

Nest Gearing (*Eng.*) A set of enclosed gear wheels.

Neurine (*Chem.*) Trimethylvinylammonium hydroxide, $(CH_3)_3N{<}^{CH=CH_2}_{OH}$. A syrupy liquid; very soluble in water; powerful alkali; very poisonous. Forms salts with acids. The picrate is sparingly soluble in cold water, easily soluble in hot water, and melts at 263°. Neurine gives precipitates with the alkaloid reagents. It is classed among the ptomaines, and is found in putrid human, horse, and ox flesh, and in the urine in Addison's disease. It can be prepared from choline (*q.v.*) by acting upon it with hydriodic acid, which converts it into the iodide $(CH_3)_3N{<}^{CH_2.CH_2I}_{I}$. The latter with moist silver oxide gives neurine. When ethylene dibromide is acted on by trimethylamine the bromide corresponding to the above iodide is produced, and this also gives neurine by heating with moist silver oxide.

Neutral (*Paint.*) A term applied to colours without predominant tone, *e.g.* in watercolour painting certain grey colours are so called.

Neutral Axis (*Eng., etc.*) The intersection of the cross section of a beam and the neutral layer. *See* BEAM. The neutral layer itself is sometimes incorrectly called the neutral axis.

Neutral Conductor, Feeder, *or* **Wire** (*Elect. Eng.*) The central or balancing wire of a THREE WIRE SYSTEM (*q.v.*)

Neutral Equilibrium (*Phys., etc.*) A body is in neutral equilibrium if on receiving a small displacement there is no tendency for this displacement, either to increase as in UNSTABLE EQUILIBRIUM (*q.v.*), or to decrease as in STABLE EQUILIBRIUM (*q.v.*) *See* EQUILIBRIUM NEUTRAL.

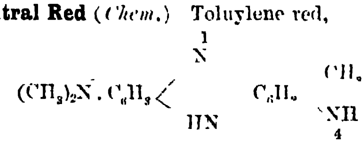
Neutralisation (*Chem.*) The process of adding a base to an acid or an acid to a base till the product has the reaction of neither. A base turns red litmus blue, while an acid turns blue litmus red; at the neutral point the product has no action on either red or blue litmus.

Neutral Layer (*Eng., etc.*) The part of a loaded beam in which there is no stress. *See also* BEAM.

Neutral Line (*Eng.*) The NEUTRAL AXIS (*q.v.*)

Neutral Points of a Dynamo (*Elect. Eng.*) Two points on the commutator (at the extremities of a diameter) at which the brushes must rest, in order that the current may be led away without sparking at the brushes. *See also* DYNAMO.

Neutral Red (*Chem.*) Toluylene red,



Orange red needles which contain four molecules water of crystallisation: this water is expelled at 150°, leaving the blood red anhydrous base. Soluble in alcohol and ether with strong fluorescence. Its hydrochloride is a red dye; it dyes cotton mordanted with tannin. It is prepared by oxidising a mixture of dimethylparaphenylenediamine and metatoluylenediamine. Neutral red is used in bacteriology. The B. coli communis a common intestinal bacterium —has the power of reducing a solution of neutral

red, thus changing its colour to a yellow. If a water coloured by this dye is changed to a yellow colour it is *one* indication of the presence of the above organism, and therefore of the presence of sewage.

Neutral Temperature (*Phys.*) *See* THERMO-ELECTRIC JUNCTION.

Neutral Tint (*Paint.*) An artist's watercolour, made by mixing Indian ink and Chinese blue with a little madder. The result is a pleasing grey having a slightly violet hue.

New Blue (*Dec.*) A permanent blue of great purity, permanent in oil and water and valuable for decorators' purposes. It is a variety of artificial ultramarine blue, and ranges in colour from a greenish to a violet hue.

Newel (*Join.*) A column supporting a handrail, *e.g.* the column at the commencement of the balusters on a staircase.

Newel Steps (*Join., etc.*) Winding steps supported by a newel formed on the narrow ends of the steps.

New Moon (*Astron.*) The moon in such a position that its longitude is the same as that of the sun. When "new" the moon is invisible. During total solar eclipses the moon is "new."

New Star (*Astron.*) When in any particular part of the heavens a star suddenly appears where no star had ever been observed before, a "new star" is said to have made its appearance.

Newtonian Constant of Gravitation (*Phys.*) *See* GRAVITATION.

Newtonian Telescope (*Astron.*) The form of reflecting telescope mostly used, in which the light from the object observed, after being reflected from the surface of a parabolic mirror, falls on a small plane mirror, placed in the optical axis of the first, at an angle of 45°, and is viewed from the side of the telescope tube.

Newton's Law of Cooling. Under certain conditions, the rate at which a hot body cools (*i.e.* the amount of heat emitted per unit time) is proportional to the difference of temperature between the hot body and the surrounding medium.

Newton's Rings. A series of coloured rings produced when two transparent curved surfaces, of different radii, are placed in contact, *e.g.* when a convex lens of large radius is pressed against a plane sheet of glass. The rings surround the point of contact, and are formed both by reflected and by transmitted light.

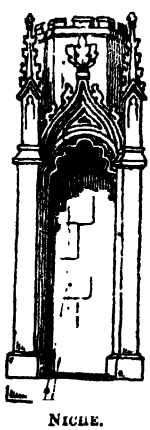
New Zealand Flax (*Botany*). A strong useful fibre obtained from the veins of the leaves of the plant *Phormium tenax* (order, *Liliaceæ*). Used in the manufacture of baskets and ropes.

Ni (*Chem.*) The symbol for NICKEL (*q.v.*)

Nib (*Build.*) A projection on the back of a tile, for fixing to the battens.

Niccolite (*Min.*) A synonym for KUPFERNICKEL (*q.v.*)

Niche (*Architect.*) A recess in a wall, generally intended for the reception of a statue. The plan of the recess is either rectangular, segmental, or semicircular, the last being the most common form.



NICHE.

Nicholson's Hydrometer. *See* HYDROMETER, NICHOLSON'S.

Nicholson's Machine (*Typog.*) A printing machine patented by William Nicholson, 1790. The first machine built with a cylindrical impression motion and mechanical inking contrivance.

Nichol's Prism (*Light*). *See* POLARISATION.

Nick (*Typog.*) A groove in the front of the shank of a type. It makes a distinction between different sorts and sizes, and enables the compositor to lift it in proper position.

Nickel (Ni). Atomic weight, 58·7. A hard white metal capable of a high polish; melts at a rather lower temperature than iron; specific gravity 8·9; it is magnetic; in its chemical properties it resembles iron, but it is less easily oxidised, hence the use of nickel plating. Red-hot nickel only decomposes steam slowly, forming the monoxide. Hydrochloric and sulphuric acids slowly dissolve it. Concentrated nitric acid causes it to assume the passive state just as it does iron (*q.v.*); dilute nitric acid readily dissolves it. Finely divided nickel combines with carbon monoxide between 30° and 80° to form nickel carbonyl, $Ni(CO)_4$. It occurs as kupfernickel, NiAs; pyrrhotite, a magnetic pyrites in which iron is replaced by nickel to the extent of 5 per cent. of the latter or more; nickel glance, NiAsS; pentlandite, (NiFe)S; garnierite, $2\left\{(Ni.Mg)_5Si_4O_{13}\right\}3H_2O$. It is found with iron in meteorites. Many methods are in use for its extraction, owing to the great variety of its ores. The Mond process is now worked on a large scale in South Wales. The Canadian ores (chiefly pyrrhotite) are roasted, then melted with coke in a blast furnace; the product is then oxidised in a Bessemer converter. This product, containing about 40 per cent of nickel, is brought to South Wales and treated by the Mond process, which is, in brief: (1) roasting of the "matt"; (*b*) reduction by water gas below 400°; (*c*) treatment in a special vessel by carbon monoxide at 80° to form nickel carbonyl; (*d*) decomposition of the nickel carbonyl at 180° in special tubes where the nickel is deposited, and the carbon monoxide is used over again. The carbon monoxide required is made from products of combustion by purifying the smoke and passing it over heated coke. The nickel is melted and cast into the form required. In America, where most nickel is extracted, an electrolytic process is employed, the ore being first submitted to a preliminary treatment like that for the Mond process. Nickel is much used for electroplating (*q.v.*); in making coins, both alloyed with other metals and pure (0·98 fine); in making German silver (*q.v.*) and nickel steel. *See* IRON. Finely divided nickel acts as a catalytic agent in bringing about the union of hydrogen and certain unsaturated compounds, especially hydrocarbons; *e.g.* vapour of benzene and hydrogen passed over it at 180° to 200° give hexahydrobenzene; homologues of benzene behave similarly. *See also* METHANE.

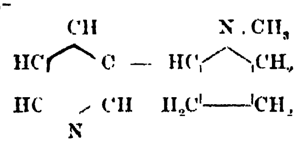
Nickel Compounds. NICKEL OXIDE, NiO, is a green powder; melts in the electric furnace and forms green crystals on solidification. Reduced to the metal on heating in hydrogen, or in carbon monoxide,

or with carbon (at 550°), carbon dioxide being formed in this case. It behaves as a basic oxide. It is obtained by heating the hydroxide or nitrate. Nickel sulphide, NiS, is a yellow solid in the natural state (millerite) or when obtained by heating nickel and sulphur together; a black powder when obtained by adding ammonium sulphide to a solution of a nickel salt; it is insoluble in dilute hydrochloric acid, but it dissolves in ammonium sulphide—this is a useful distinction from cobalt. NICKEL SULPHATE, $NiSO_4$, is a yellow solid when anhydrous; but the ordinary crystallised salt, $NiSO_4 6H_2O$, is green. Nickel sulphate is very soluble in water (37·4 $NiSO_4$ in 100 at 16°); the crystallised salt loses $5H_2O$ at 100°, and becomes anhydrous above 280°. It is obtained by dissolving the metal, its hydroxide or carbonate, in dilute sulphuric acid. It combines with ammonium sulphate to form the double salt $(NH_4)_2SO_4NiSO_4 6_2HO$. This salt is used in nickel plating; also, by electrolysis of its solution, made alkaline with ammonia, chemically pure nickel can be obtained. NICKEL CYANIDE, $Ni(CN)_2$, is obtained as a green precipitate on adding potassium cyanide solution to a solution of a nickel salt; it dissolves in excess, forming $K_2Ni(CN)_4$, but no salt corresponding to the cobalticyanides. Hypochlorites or hypobromites give black hydrated nickelic oxide with this double salt—distinction from the cobalticyanides. NICKELIC OXIDE, Ni_2O_3, is a black powder obtained by gently heating the nitrate; its hydrate, $Ni_2O_3 3H_2O$, is obtained by adding a hypochlorite or hypobromite solution to any solution of a nickel salt. Its behaviour is that of a peroxide. *See* OXIDES. NICKEL CARBONYL, $Ni(CO)_4$, is a colourless liquid; boils at 40°, and has a normal vapour density—the vapour explodes at 60°. In an inert gas it can be heated without explosion, but it dissociates: in nitrogen dissociation is complete at 155°. It is soluble in alcohol, benzene, chloroform. It burns in air with a white flame. Its vapour is poisonous and the action is characteristic—and not carbon monoxide poisoning. To prepare it nickel oxide is reduced in hydrogen at about 400°; the reduced nickel is allowed to cool to from 30° to 80°, and carbon monoxide is passed over it, and the escaping gas cooled by ice and salt when the nickel carbonyl condenses.

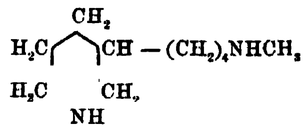
Nickel Pyrites (*Min.*) A synonym for Millerite (*q.v.*)

Nicker (*Carp., etc.*) The cutting lip of certain forms of bits used in boring wood.

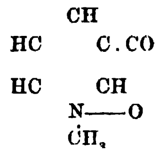
Nicotine-



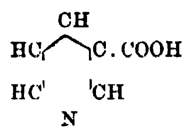
(β-pyridine-N-methyl-α-pyrrolidine). A colourless oily liquid; boils at 247°; has a mouse-like smell when pure, but smells like tobacco when impure; extremely poisonous; optically active, being lævorotatory; soluble in water and the usual organic solvents; turns brown on exposure to air. It is basic, and forms a number of salts. Nicotine occurs in tobacco leaves to a very variable amount—from 0·5 to 8 per cent.; tobacco smoke also contains nicotine. It is obtained from tobacco leaves by soaking them in acidulated water, concentrating the extract, adding quicklime, and distilling; the crude alkaline distillate is neutralised with oxalic acid and evaporated; on adding concentrated caustic potash the nicotine separates, and is extracted with ether; on distilling off the ether finally in a stream of hydrogen the pure base can be distilled over. The following reactions of nicotine are important: it can add two, six, or eight atoms of hydrogen; in the last case the pyrrolidine ring is probably opened—



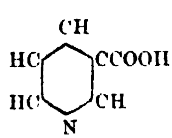
It forms two isomeric iodomethylates: (1) by treating its hydriodide in boiling alcoholic solution with methyl iodide and neutralising with caustic soda—this iodomethylate yields a hydroxide with moist silver oxide, which on oxidation with potassium permanganate gives trigonelline—



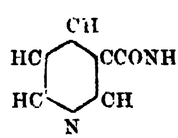
showing that the methyl iodide has added itself to the pyridine nitrogen. (2) By mixing methyl alcohol solutions of nicotine and methyl iodide, when the methyl iodide adds itself to the pyrrolidine nitrogen: thus nicotine is a ditertiary base. When an aqueous solution of nicotine is boiled with silver oxide it gives nicotyrine; on oxidation nicotine yields nicotinic acid, which has the formula—



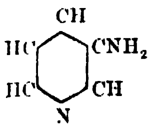
Nicotine has been synthesised as follows: From nicotinic acid (*see* PYRIDINE) the amide can be prepared by treating its ethyl ester with ammonia. Sodium hypobromite converts the amide into β-aminopyridine. The latter, when heated with mucic acid, yields β-pyridyl-N-pyrrole, which undergoes intramolecular rearrangement on passing it through a tube heated to low redness to β-pyridyl-α-pyrrole. The potassium compound of β-pyridyl-α-pyrrole, on treatment with methyl iodide, yields the iodomethylate of nicotyrine, which is identical with the iodomethylate of nicotyrine obtained from natural nicotine. From nicotyrine, by action of a solution of iodine in caustic soda, iodonicotyrine is obtained, which on reduction with zinc and hydrochloric acid, gives dihydronicotyrine, a liquid strongly resembling nicotine itself. On brominating the last product and reducing the dibromide with tin and hydrochloric acid, inactive nicotine is obtained, which can be resolved into active nicotine by fractional crystallisation of its tartrate—



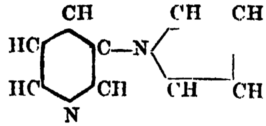
Nicotinic Acid.



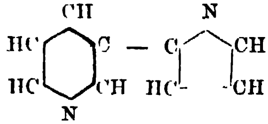
Nicotinic Acid Amide.



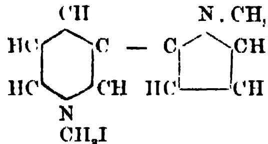
β-aminopyridine.



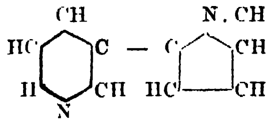
β-pyridyl-N-pyrrole.



β-pyridyl-α-pyrrole.



Nicotyrine Iodomethylate.



Nicotyrine.

The only step which has not been taken is the conversion of nicotyrine iodomethylate into nicotyrine.

Niello. A process of ornamenting metal plates by cutting a design upon the surface, the incisions being then filled in with a black or coloured composition. The best examples are those by Italian artists of the fifteenth century.

Niger Seed Oil. Made from Niger seed, the product of an Abyssinian plant, either by hot or cold pressure, after grinding. The colour is similar to olive oil, the specific gravity ·924. It has poor drying qualities, and is principally used in India for food.

Nimbus (*Art*). The halo or disc surrounding the head in representations of saints. *See* AUREOLA.

Nimbus Clouds (*Meteorol.*) A class of cloud. It is the cloud of continued rain or snow. Has ragged edges. *See* CLOUDS.

Niobium (*Chem.*) Nb. Atomic weight, 94. A rare metal belonging to the nitrogen group in the periodic system (*q.v.*) It occurs in columbite (the Americans call the metal columbium), yttrotantalite, euxenite.

Nippers (*Eng., etc.*) Pliers, either for holding or for cutting metal, etc.

Nipple (*Gas Fitting, etc.*) A piece of pipe with a male thread cut the whole of its length.

Nipples (*Cycles*). Small tubular nuts used to fix the heads of spokes to the rim of the machine.

Nitrates. Salts or esters of nitric acid, derived from the acid by replacement of its hydrogen by a metal or alcohol radical.

HNO_3 Nitric Acid.	KNO_3 Potassium Nitrate.	$C_2H_5 . NO_3$ Ethyl Nitrate.
HNO_3 HNO_3	$Pb\langle^{NO_3}_{NO_3}$ Lead Nitrate.	$Cu\langle^{NO_3}_{NO_3}$ Copper Nitrate.
HNO_3 HNO_3 HNO_3	$Bi(NO_3)_3$ Bismuth Nitrate.	$CH_2 . NO_3 — CH . NO_3 — CH_2 . NO_3$ Glyceryl Trinitrate (Nitroglycerine).

The nitrates are prepared by dissolving the metal, its oxide, or its carbonate, whichever is most convenient, in nitric acid, and crystallising the solution; or in the case of the esters the alcohol is treated with nitric acid, or, as in the case of nitroglycerine, with a mixture of nitric and sulphuric acids. Some nitrates occur naturally, *e.g.* sodium and potassium nitrates. The metallic nitrates are soluble in water, except in a few cases, where the nitrate is decomposed by water, forming basic nitrates, which are insoluble in water. The common metals which form basic nitrates are bismuth and mercury. The nitrates of these metals easily dissolve in water acidified with nitric acid. The effect of heating nitrates is as follows: Ammonium nitrate gives nitrous oxide and water; potassium and sodium nitrates at low redness give the corresponding nitrites, but at higher temperatures a mixture of oxides; other nitrates give oxygen, nitrogen peroxide, and a metallic oxide, or, if the oxide itself is easily decomposed by heat, the metal and oxygen. Most nitrates are insoluble in concentrated nitric acid. Nascent hydrogen reduces their solutions to nitrite, then to ammonia. The nitrates of alcohol radicals (nitric acid esters) are liquids unless the alcohol has a high molecular weight, when they are solid, and explosive on moderate heating or on detonation; they are hydrolysed like other esters. Ethyl nitrate, on reduction with tin and hydrochloric acid, yields hydroxylamine. For particular nitrates *see under* the various metals and alcohol radicals.

Nitrates in Water. *See* SANITATION.

Nitre (*Chem.*) A common name for potassium nitrate. *See* POTASSIUM COMPOUNDS.

—— (*Min.*) Potassium nitrate, KNO_3. Potash = 46·6, nitric acid = 53·4 per cent. Orthorhombic in prismatic crystals, also as an encrustation. Soluble in water. The chief supply comes from the soils of certain districts in India, Egypt, Persia, etc.

Nitric Acid (*Chem.*) Aqua fortis, HNO_3. A colourless liquid. Boils with decomposition at 86°, $2HNO_3 = H_2O + 2NO_2 + O$, hence the acid changes composition on distillation, becoming weaker, till at 760 mm. the boiling point has risen to 120°, when an acid of 68 per cent., HNO_3 (sp. gr. 1·414 at 15°), distils unchanged. Nitric acid eagerly absorbs water from the air, and as the strong acid is volatile it fumes in air, owing to the water vapour present in it. The strongest nitric acid, which can be prepared in the usual way (*see* below), corresponds to 99·975 per per cent., HNO_3; but it seems very doubtful if strong nitric acid has the composition HNO_3 at all. The kind of evidence on which this statement is based is the following. The electrical conductivity of nitric acid increases from a 1·3 to a 30 per cent. solution, HNO_3, then diminishes slowly to 76 per cent., then rapidly to 96·12 per cent., whence it increases again; also from 96·12 per cent. upwards the conductivity diminishes with increase of temperature like that of a metal. Similar irregularities show themselves in the case of other physical constants

such as refractive index, absorption of ultra-violet light, magnetic rotation, contraction on dilution with water. It is inferred that such changes can only be caused by changes in chemical composition. Professor Hartley thinks the strongest acid may have the formula $H_2N_2O_6$; while an acid = 89·6 per cent., HNO_3, may be a mixture of $H_2N_2O_6$ and H_3NO_4. The strongest acid obtainable differs considerably in chemical behaviour from ordinary or from fuming nitric acid, in that it has no action at the ordinary temperature on many metals, such as copper, silver, mercury, magnesium, which are readily acted on by ordinary nitric acid, and tin is not acted on even when boiled with it. Calcium carbonate is also unattacked by the boiling acid; but it readily oxidises sulphur, and nitrates organic compounds. Ordinary nitric acid has the following chemical behaviour: (*a*) It acts as a strong monobasic acid. (*b*) It oxidises many non-metals, *e.g.* carbon to carbon dioxide, iodine to iodic acid, HIO_3, phosphorus to phosphoric acid, arsenic to arsenic acid, sulphur to sulphuric acid. (*c*) It oxidises various "-ous" salts to "ic" salts, *e.g.*

$$6FeSO_4 + 8HNO_3 = 2Fe_2(SO_4)_3 + Fe_2(NO_3)_6 + 2NO + 4H_2O.$$

(*d*) Its action on sulphides depends on the strength of the acid. A diluted acid will give a nitrate and liberate sulphur (sulphuretted hydrogen may be formed and oxidised to water and sulphur), while the strong acid will oxidise the sulphide to sulphate. (*e*) Its action on metals seems to be dependent on the presence of nitrous acid; for when the acid is freed from nitrous acid, its action on metals is extremely slow, and its rate of action increases with increase in amount of nitrous acid. The nitrous acid seems to arise in the first place from electrolytic action set up between the metal and traces of impurities contained in it. The nitrous acid forms a nitrite of the metal, and the nitrite is decomposed by the nitric acid. In the case of copper the reactions are:

$$Cu + 4HNO_2 = Cu(NO_2)_2 + 2H_2O + 2NO$$
$$Cu(NO_2)_2 + 2HNO_3 = Cu(NO_3)_2 + 2HNO_2$$
$$2NO + H_2O + HNO_3 = 3HNO_2$$

When the nitrous acid reaches a certain concentration the third reaction becomes reversible, and at this stage nitric oxide escapes. But other reactions occur too, owing to decomposition of the acids in other ways; thus with copper and nitric acid of sp. gr. 1·2, besides 90 per cent. of nitric oxide, 10 per cent. of nitrogen peroxide is evolved, while with acid of sp. gr. 1·3 and over the only products are nitrogen trioxide and peroxide. Nitric acid acts on silver, bismuth, and mercury very much in the same way as on copper. With lead the reduction products are different—40 per cent. nitrous oxide, 50 per cent. nitric oxide, and 2·5 per cent. nitrogen peroxide. In general, when nitric acid acts on metals, a nitrate is produced and reduction products of the acid, which vary with the nature of the metal, concentration of acid, and temperature. Ammonia is among the reduction products when the dilute acid acts on tin and iron, and even hydrogen is evolved as such when the acid acts on magnesium. (*d*) On organic compounds it acts: (1) As an oxidising agent; *e.g.* cane sugar is oxidised to oxalic acid. (2) On fatty compounds containing hydroxyl groups to form nitrates. This action occurs in absence of nitrous acid and in presence, as usual, in case of ester formation, of a dehydrating agent; *e.g.* cane sugar gives an octonitrate with concentrated nitric and sulphuric acids. The preparation of nitro-glycerine and gun cotton are other examples of the formation of nitrates. *See also* ETHYL NITRATE. (3) To form nitro-compounds, *e.g.* Nitrobenzene (*q.v.*) Nitric acid is formed in the atmosphere during electric discharges. Nitrogen combines with oxygen to form nitric oxide, which then unites with a further quantity of oxygen to form the peroxide, and the latter in contact with water gives nitric acid, $3NO_2 + H_2O = 2HNO_3 + NO$. This change has been imitated on a manufacturing scale for the production of nitric acid. Ordinarily the acid is prepared by distilling potassium nitrate with sulphuric acid on the laboratory scale, or sodium nitrate in place of the potassium salt on a manufacturing scale. The distillate is always yellow on account of dissolved nitrogen peroxide, and it contains water and other impurities. To remove water it is mixed with concentrated sulphuric acid and redistilled; to remove nitrogen peroxide dry air is passed through the acid at a temperature not exceeding 35°C. The air used should be filtered through glass wool to remove dust. Such pure strong acid must be kept in the dark, as it is decomposed by light, the nitrogen peroxide again forming and turning the acid yellow. A very strong acid of sp. gr. 1·5 and rather over, and of a yellowish red colour, is much used in organic chemistry under the name of "fuming nitric acid" for making nitro compounds. This acid is produced by using acid and nitrate in the proportions required by the equation

$$2KNO_3 + H_2SO_4 = K_2SO_4 + 2HNO_3,$$

and working at a higher temperature when a part of the nitric acid decomposes, giving nitrogen peroxide, to which the acid owes its red tint. Ordinarily more sulphuric acid than this is used; or more sulphuric acid may be used and a little starch added, which gives with a part of the nitric acid large quantities of nitrogen peroxide. Nitric acid gives a rose colour with brucine and a deep blue colour with diphenylamine in strong sulphuric acid. Both these are delicate tests, but the latter is given by nitrites, chlorates, and other oxidising agents.

Nitric Anhydride (*Chem.*) *See* NITROGEN PENTOXIDE *under* NITROGEN OXIDES.

Nitric Oxide (*Chem.*) *See* NITROGEN OXIDES.

Nitrides (*Chem.*) Compounds formed by the union of two elements, one of which is nitrogen. The compounds of nitrogen with the commoner non-metals are not usually called nitrides; for example, the compounds of nitrogen and hydrogen have special names: NH_3 is called ammonia, N_2H_4 is called hydrazine, and the compound of nitrogen and carbon is called cyanogen, C_2N_2. The compounds of nitrogen and oxygen are called nitrogen oxides. For nitrides see under the name of the other element, *e.g.* under BORON COMPOUNDS, MAGNESIUM COMPOUNDS, etc.

Nitrification (*Chem.*) The bacteriological process by which ammonia, liberated from decaying nitrogenous organic matter or brought into soils by rain, is changed in the soils to nitrates. Two kinds of bacteria are concerned in the process, one kind oxidising the ammonia to a nitrite, and the other kind oxidising the nitrite to nitrate.

Nitriles (*Chem.*) Cyanides of organic radicals. Compounds of the formula $R^N.(CN)^N$, where R is hydrogen or a hydrocarbon residue, and N is a whole number. They are usually colourless liquids with an agreeable smell, and except the simplest members insoluble in water; *e.g.* formonitrile and acetonitrile are soluble in water, propionitrile only partly soluble in water. They are named in two ways: (*a*) from the acid formed on hydrolysis, *e.g.* acetonitrile, CH_3CN, which yields acetic acid on hydrolysis; (*b*) from the alcohol radical united to the cyanogen group, *e.g.* methyl cyanide, CH_3CN. Again, C_6H_5CN may be called benzonitrile or phenylcyanide. Nitriles can be obtained in many ways: (1) From potassium cyanide either by heating its alcoholic solution with an alkyl iodide or bromide at 100° or over, or by distilling it with an alkyl hydrogen sulphate. In both cases some of the isomeric isocyanide is formed, which may be removed by warming with dilute hydrochloric acid. The nitriles can be separated from their aqueous solutions, when they are soluble in water, by addition of calcium chloride. (2) By the action of phosphorus pentoxide on an acid amide, a reaction which goes in the case of acetamide without heating:

$$CH_3C\begin{matrix}\diagup O\\ \diagdown NH_2\end{matrix} = CH_3C\equiv N + H_2O$$

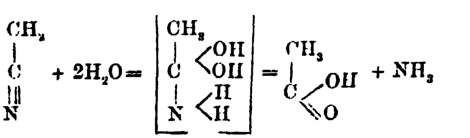
As the acid amides are themselves obtained by dehydration of ammonium salts, nitriles can be obtained directly from ammonium salts by acting on the latter with sufficient of the dehydrating agent. (3) By the action of acetic anhydride or acetyl chloride on an aldoxime; this is also a dehydrating action:

$$\underset{\text{Acetaldoxime.}}{CH_3.C\begin{matrix}\diagup H\\ \diagdown NOH\end{matrix}} + \underset{\text{Acetic Anhydride.}}{\begin{matrix}CH_3CO\\ CH_3CO\end{matrix}\!\!>\!O} = CH_3C\equiv N + 2CH_3COOH.$$

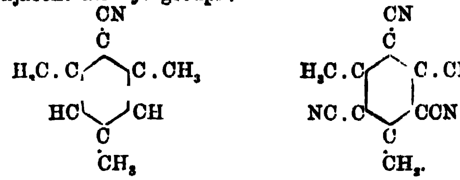
(4) Aromatic nitriles can also be obtained by the preceding methods, but are best obtained by one of the following: (*a*) From the diazo-compound by action of potassium cyanide and copper sulphate; (*b*) by distillation of potassium cyanide with the potassium salt of the corresponding sulphonic acid, *e.g.* benzonitrile:

$$\underset{\text{Potassium Benzene Sulphonate.}}{C_6H_5SO_2OK} + KCN = C_6H_5CN + K_2SO_3.$$

(*c*) From the corresponding acid by distillation with lead sulphocyanate. The nitriles have many important reactions: (1) On hydrolysis they yield first acid amides and then acids. Thus with concentrated sulphuric acid they yield the amide, taking up one molecular proportion of water from the acid, and the amide, on boiling with water, yields the acid. They are also hydrolysed by boiling with alkalis:



Certain aromatic nitriles are either not hydrolysed at all or only very slowly, *e.g.* symmetrical trimethylbenzonitrile is very difficult to hydrolyse, while s-trimethyl-tricyano-benzene cannot be hydrolysed. This is attributed to spacial hindrance by the adjacent methyl groups:



(2) On reduction (sodium and alcohol) the nitriles yield amines:

$$\begin{matrix}CH_3\\ |\\ C\\ |||\\ N\end{matrix} + 4H = \underset{\text{Ethylamine.}}{\begin{matrix}CH_3\\ |\\ CH_2\\ |\\ NH_2\end{matrix}}$$

The method of preparation (1) combined with this reaction forms a method of passing up a homologous series of alcohols, etc.:

$$CH_3OH \rightarrow CH_3I \rightarrow CH_3CN \rightarrow CH_3CH_2NH_2 \xrightarrow{HNO_2} CH_3CH_2OH$$

(3) With hydrochloric acid and with hydrochloric acid and alcohol they form imide chlorides and ethers respectively:

$$CH_3C\begin{matrix}\diagup\!\!\diagup NH\\ \diagdown Cl\end{matrix} \text{ and } CH_3C\begin{matrix}\diagup\!\!\diagup NH\\ \diagdown OC_2H_5\end{matrix}$$

(4) With organic acids and anhydrides they form secondary and tertiary amides:

$$CH_3C\equiv N + \begin{matrix}CH_3CO\\ CH_3CO\end{matrix}\!\!>\!O = N\begin{matrix}\diagup OC.CH_3\\ -OC.CH_3\\ \diagdown OC.CH_3\end{matrix}$$

(5) They undergo polymerisation on treatment with sodium. *See* KETONES.

Nitrites (*Chem.*) Salts or esters of nitrous acid (*q.v.*) The inorganic nitrites are yellowish-white crystalline solids, all soluble in water; the least soluble of them, silver nitrite, dissolves in about 300 times its weight of cold water, but easily in hot water. They are decomposed on heating, giving off nitric oxide and nitrogen peroxide, and leaving the oxide or metal behind. In some cases a nitrate is certainly formed as intermediate product. They are easily decomposed by acids, liberating the unstable nitrous acid. Oxidising agents convert them into nitrates. The nitrites of potassium, sodium, and silver are described under the compounds of those metals. The organic nitrites are volatile, colourless, or pale yellow, pleasant smelling liquids. *See* AMYL NITRITE *and* ETHYL NITRITE. They are isomeric with the corresponding nitro-compounds. Their constitution is represented thus: $R-O.NO$, because they are easily hydrolysed to alcohols and nitrites; also on reduction they yield an alcohol and ammonia, *e.g.*

$$C_2H_5O.NO + HOK = C_2H_5OH + NO.OK$$
$$C_2H_5O.NO + 6H = C_2H_5OH + NH_3 + H_2O$$

Nitrobenzene (*Chem.*) $C_6H_5NO_2$. A slightly yellow liquid which smells like oil of bitter almonds, and is therefore used, though poisonous, as a flavouring agent under the name of essence of mirbane; melts at 3°, boils at 209°; nearly insoluble in water, but easily soluble in the usual organic solvents, such as alcohol, ether, acetic acid, benzene, etc.; specific gravity, 1·2. It is obtained by gradually adding a mixture of concentrated nitric and sulphuric acids

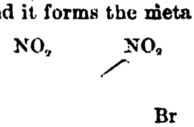
(12 parts to 18 parts) to benzene (10 parts), with constant stirring, and cooling so as to keep the temperature below 25° at first; when most of the acid has been added, the temperature may be allowed to rise, but not over 50°. After standing, the lower layer of acid is run away, and the nitrobenzene well washed by water, or if required very pure, distilled in steam; it can be dried over calcium chloride. On reduction with an acid reducing agent it yields aniline (*q.v.*); with a neutral reducing agent such as aluminium amalgam and water it yields, in ether solution, an intermediate product, phenylhydroxylamine. *See* NITROSO COMPOUNDS. With alcoholic potash or sodium amalgam and alcohol, etc., it yields azoxybenzene (*q.v.*):

$$2C_6H_5N\begin{smallmatrix}\nearrow O\\ \searrow O\end{smallmatrix} + 6H = C_6H_5.N - N.C_6H_5 + 3H_2O.$$
$$\qquad\qquad\qquad\qquad \diagdown O \diagup$$

See also QUINOLINE. On electrolytic reduction in strong acid solution it yields paramidophenol:

$$C_6H_5N\begin{smallmatrix}\nearrow O\\ \searrow O\end{smallmatrix} \rightarrow C_6H_5N\left\langle\begin{smallmatrix}H\\ OH\end{smallmatrix}\right. \quad HO.C_6H_4NH_2.$$

On further nitration it yields metadinitrobenzene, HNO_3, 70 : H_2SO_4, 100 : $C_6H_5NO_2$. 100 parts. Temperature 70° to 100°), which is a slightly yellowish crystalline solid melting at 90°. Nitrobenzene is only acted on by bromine and chlorine to form substitution products, when a halogen carrier, $FeCl_3$, is present, and it forms the meta derivative



Nitro-Compounds (*Chem.*) Compounds of the formula $R^N(NO_2)_N$, when R is an organic residue which may be of any degree of complexity, and N represents the valency of R. They are divided into two well defined groups, *viz.* (*a*) fatty nitro-compounds, (*b*) aromatic nitro-compounds. The fatty nitro-compounds cannot, as a rule, be obtained by the direct action of nitric acid on the hydrocarbon. In some of the higher paraffin hydrocarbons direct nitration can be effected by nitric acid, but the process is accompanied by oxidation. Thus normal hexane is nitrated by nitric acid when boiled with it for several days, yielding a mono- and a dinitrohexane; the higher paraffins are more easily nitrated, and the iso-paraffins still more easily. The nitroparaffins are usually obtained by the action of silver nitrite on an alkyl iodide, when they are usually obtained mixed with the isomeric nitrite, from which they can be separated by fractional distillation, the nitro-compound having the higher boiling point. They are colourless liquids, not hydrolysed by caustic soda as the nitrites are; on reduction they yield hydroxylamines, then amines. With alcoholic soda or sodium ethoxide, primary nitro-paraffins form sodium salts, which are explosive. Because of this salt formation it is assumed that the primary nitro-paraffins can have two isomeric forms; *e.g.*

$$(1)\ CH_3CH_2NO_2,\ \text{and}\ (2)\ CH_3C\begin{smallmatrix}\diagup H\\ \diagdown\!\diagdown NO.OH\end{smallmatrix}$$

Form (1) being stable, Form (2) being unstable and giving rise to the salts. The two forms have not been obtained in the case of the simple nitro-paraffins, but they have been obtained in the case of phenylnitro-methane:

$$(1)\ C_6H_5CH_2NO_2,\ (2)\ C_6H_5C\begin{smallmatrix}\diagup H\\ \diagdown\!\diagdown NO.OH\end{smallmatrix}$$

Form (2) is obtained by making the sodium salt and acidifying it, when Form (2) separates as a crystalline solid, while Form (1) is an oily liquid. *See* PSEUDO-ACIDS. An interesting reaction of the sodium salt of nitro-methane is the formation of mercury fulminate when its solution is added to a solution of mercuric chloride:

$$2\begin{smallmatrix}H\\ H\end{smallmatrix}\!\!>\!C = NO.ONa + HgCl_2 = 2H_2O + (C = NO)_2Hg + 2NaCl.$$

The action of nitrous acid on the nitro-paraffins is dependent on the position of the nitro-group. Primary nitro-paraffins yield nitrolic acids, secondary pseudo-nitrols, tertiary are unacted on. The equations make this statement clear:

$$\underset{\text{Nitro ethane.}}{CH_3.C\begin{smallmatrix}\diagup H\\ - H\\ \diagdown NO_2\end{smallmatrix}} + ON.OH = \underset{\text{Methyl Nitrolic Acid.}}{\overset{CH_3}{\overset{|}{C}}\begin{smallmatrix}\diagup\!\diagup NOH\\ \diagdown NO_2\end{smallmatrix}} + H_2O$$

$$\underset{\text{Isonitropropane.}}{(CH_3)_2C\left\langle\begin{smallmatrix}H\\ NO_2\end{smallmatrix}\right.} + ON.OH = \underset{\text{Isopropylpseudonitrol.}}{(CH_3)_2C\left\langle\begin{smallmatrix}NO\\ NO_2\end{smallmatrix}\right.} + H_2O$$

$$\underset{\text{Tertiary Nitrobutane.}}{(CH_3)_3C.NO_2} + ON.OH = \text{No action.}$$

The nitrolic acids are colourless, but yield red sodium salts, while the pseudo-nitrols are blue. *See* NITROSO-COMPOUNDS. The aromatic nitro-compounds are usually obtained by direct nitration; that is to say, by the direct action of nitric acid of various strengths, or by the direct action of a mixture of nitric and sulphuric acids, the sulphuric acid acting as a dehydrating agent, on the compound whose nitro-derivative is required; examples of direct nitration are given under nitro-benzene and picric acid. But some aromatic compounds cannot be directly nitrated, *e.g.* the amines. To nitrate amines they are converted into salts or acid derivatives. Thus to nitrate aniline it may be converted into sulphate by addition of a large excess of sulphuric acid and then nitrated, or it may be converted into acetanilide, and the acetanilide nitrated. On nitrating benzene and its derivatives certain regularities are observed. If one nitro-group is already present a second nitro-group will assume the meta-position with respect to the first; if other groups are present, the rule is as follows: with an unsaturated group already present the nitro-group goes chiefly into the meta-position, but with a saturated group it takes the para- or ortho-position; *e.g.* groups

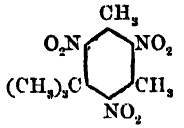
$$-N\begin{smallmatrix}\diagup O\\ \diagdown\!\diagdown O\end{smallmatrix},\ -C\begin{smallmatrix}\diagup OH\\ \diagdown\!\diagdown O\end{smallmatrix},\ -C\begin{smallmatrix}\diagup H\\ \diagdown\!\diagdown O\end{smallmatrix},\ -S\begin{smallmatrix}\diagup\!\diagup O\\ \Leftarrow O\\ \diagdown OH\end{smallmatrix},\ -C \equiv N,$$

are unsaturated; groups

$$Cl,\ Br,\ -N\left\langle\begin{smallmatrix}R\\ H\end{smallmatrix}\right.,\ -OH,\ -OCH_3,\ -CH_2R,$$

are saturated (R is hydrogen or any monovalent element or group). The aromatic nitro-compounds are usually yellow liquids or solids of pleasant smell. But paranitrophenol is white, and only its salts are coloured. Nitrobenzene smells of almonds, and

1 : 3 : 5-dimethyltertiarybutyltrinitrobenzene has a powerful smell of musk (artificial musk).



The nitro-compounds of aromatic substances are very important because on reduction they yield amines which are of extreme importance in dye making and in the preparation of other aromatic compounds. *See* DIAZO-REACTION. For the reactions of a typical nitro-compound *see* NITROBENZENE. *See also under* NAPHTHALENE *and* NAPHTHOLS.

Nitrogen (*Chem.*) N. Atomic weight, 14. A colourless gas; no smell; melts at $-214°$; boils at 194°; slightly soluble in water (100 cc. water dissolve $1\frac{3}{8}$ cc. at 15° and 760 mm.) Unites, but only at high temperature, with a large number of other elements. Examples: (1) With hydrogen under the influence of electric sparks, where the yield of ammonia is only about 0·2 per cent., owing to the reversible character of the reaction. If, however, a little dilute sulphuric acid is present to take up the ammonia, the whole of the nitrogen can be converted into ammonia. (2) With oxygen. When electric sparks from a large induction coil are passed in air the oxygen burns in the nitrogen to form nitric oxide. *See* NITRIC ACID. (3) With magnesium. When nitrogen is passed over heated magnesium the nitride is formed. Boron, cerium, and lanthanum all burn in the gas when heated, the two last at the moderate temperature of 260°. Nitrogen forms about four-fifths by volume of the atmosphere (*q.v.*); it is, in combination, a necessary constituent of all plants and animals, and certain plants are able through the agency of bacteria to assimilate the element directly. To obtain it chlorine is passed through excess of the strongest ammonia.

$$\left\{\begin{array}{l} 2NH_3 + 3Cl_2 = N_2 + 6HCl \\ 6NH_3 + 6HCl_2 = 6NH_4Cl \end{array}\right\}$$

Or strong solutions of sodium nitrite and ammonium chloride are mixed in molecular proportions, and the mixture is gently warmed.

$$NaNO_2 + NH_4Cl = NaCl + 2H_2O + N_2.$$

Many attempts have been made to utilise the atmospheric nitrogen—for example, in the preparation of nitric acid (*q.v.*) When nitrogen is passed over heated calcium carbide a mixture of calcium cyanide and cyanamide results. The latter on heating with carbon and common salt is changed to calcium cyanide. From calcium cyanide either alkaline cyanides can be prepared by the action of alkaline carbonates or ammonia can be prepared by heating it with water under pressure:

$$Ca(CN)_2 + 3H_2O = CaCO_3 + 2NH_3.$$

Nitrogen Chloride (*Chem.*) NCl_3. A pale yellow liquid; its sp. gr. is about 1·6 (it sinks very slowly in a solution of ferric sulphate, sp. gr. 1·578. Porret, Wilson, and Kirk, 1813); very explosive; its vapour strongly affects the eyes and mucous membrane of the respiratory passages, so that it is a dangerous substance to work with apart from its properties as an explosive. On heating, it explodes at 95°. Direct sunlight or burning magnesium wire causes it to explode. It is decomposed by ammonia into nitrogen and hydrochloric acid, and by means of this reaction Gattermann analysed his pure nitrogen chloride. Contact with organic matter, such as wood or turpentine, causes it to explode instantly. But a solution in benzene (5 to 10 per cent.) has been used as a chlorinating agent; thus it converts aniline, or, for a better yield, aniline hydrochloride, into trichloraniline hydrochloride. It is best prepared by the action of chlorine on a warm and saturated solution of ammonium chloride; the oil so obtained is washed with water, then treated with a stream of chlorine; finally it is separated, washed, dried over fused calcium chloride. It can also be obtained by the electrolysis of a solution of ammonium chloride.

Nitrogen in Food. Is essential for the growth, maintenance, repair, and functional activity of the tissues. The amount of nitrogen in diet for an adult in ordinary work varies from 250 to 350 grains. In the best diets the proportion of nitrogen to carbon is about 1 to 15. *See* FOODS.

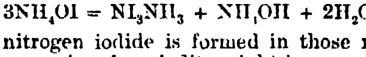
Nitrogen Iodide (*Chem.*) $NI_3 . NH_3$. The pure substance NI_3 has not been prepared. The substance of the above formula ($NI_3 . NH_3$) is a black powder, or, when prepared as described below, a lustrous reddish crystalline solid. It easily explodes on percussion or friction when dry; it is also decomposed by light; in the visible spectrum the red rays decompose it fastest. The products of decomposition by light are nitrogen and ammonium iodide and iodate. It is decomposed by water, acids, and alkalis. The reactions usually proceed quietly in the cold, but with explosion on warming. The explanation of its modes of formation and decomposition is to be found in the reversible reaction—

$$3NH_4OI = NI_3NH_3 + NH_4OH + 2H_2O.$$

Hence nitrogen iodide is formed in those reactions where ammonium hypoiodite might be expected, and the first step in its decomposition is the reformation of ammonium hypoiodite. Thus nitrogen iodide is decomposed by caustic potash as follows:

$$NH_3NI_3 + 3KOH = 2NH_3 + 3KOI$$
$$3KOI = KIO_3 + 2KI.$$

It can be prepared by the action of ammonia on iodine or in crystallised state as follows: iodine (100 gr.), concentrated hydrochloric acid (300 cc.), and concentrated nitric acid (28 cc.) are heated not above 40° till all the iodine is dissolved, and a solution of iodine chloride, ICl, is formed; it is then boiled to expel nitrosyl chloride. A quantity of this solution containing 12·7 gr. of iodine is made up to 1 litre; this solution is used 15 cc. at a time, each lot is added to 100 cc. of 3 per cent. caustic potash, and then 10 cc. of strongest ammonia are added, and the whole shaken. The iodide crystallises out (Chattaway & Orton). Dr. Chattaway (private communication) has prepared tribenzylamine from nitrogen iodide by acting upon it with benzyl iodide in presence of magnesium and ether, thus showing that it contains the group NI_3.



Nitrogen Oxides (*Chem.*) (1) NITROUS OXIDE, N_2O, LAUGHING GAS. The anhydride of hyponitrous acid. A colourless heavy gas; no smell. Produces temporary unconsciousness when inhaled, hence its use in minor surgical operations; and it does this even when mixed with oxygen. Melts at $-99°$; boils at $-90°$. Somewhat soluble in water (78 cc. in 100 cc. at 15° and 760 mm.) Substances which burn in oxygen burn in nitrous oxide when heated to such

a temperature as will decompose it; and as the gas is an endothermic compound, the heat evolved in such combustions is greater than that evolved in an equivalent quantity of oxygen by the heat of formation of the nitrous oxide. The products are the oxide of the substance burnt and a volume of nitrogen equal to the volume of nitrous oxide employed. It is obtained by the decomposition of the corresponding acid, hyponitrous acid (*q.v.*); but hyponitrous acid has not yet been prepared from nitrous oxide; by reducing a solution of sodium nitrite with sodium amalgam at a low temperature; by the action of dilute nitric acid on zinc. But to obtain it in quantity ammonium nitrate is heated at 240°, $NH_4NO_3 = N_2O + 2H_2O$. For inhalation the nitrate used should be free from chloride, and the gas obtained from it should be passed through ferrous sulphate solution to remove traces of nitric oxide which may be present. (2) NITRIC OXIDE, NO. A colourless gas. Melts at −167°; boils at −154°. Very slightly soluble in water; only decomposed by heat at a very high temperature. Substances which burn in oxygen burn in this gas when heated to a sufficiently high temperature to decompose it, the oxygen forming oxides and the nitrogen being, as a rule, set free, and measuring half the volume of the nitric oxide taken. It unites with oxygen to form nitrogen peroxide, NO_2, unless both gases are absolutely dry, when no union occurs. It is absorbed by solutions of ferrous salts, chromous salts, stannous salts, and mercurous salts. With ferrous sulphate a dark brown solution is obtained, the formation of which serves as a test for nitric acid (*see* below) and as a means of purifying nitric oxide (*see* below). Nitric oxide is perfectly absorbed by a strong solution of sodium sulphite containing some caustic soda, forming sodium hyponitrososulphate, $Na_2N_2O_2SO_3$, the best method of absorption in gas analysis. It is reduced to nitrous oxide by zinc in presence of water. Solution of stannous hydroxide in excess of caustic potash reduces it to potassium hyponitrite. Nitric oxide is formed by the direct union of its elements. Usually it is obtained by the action of copper on nitric acid (*q.v.*), but it is then impure. To purify it the gas is passed into a saturated ferrous sulphate solution, and nitrous oxide and nitrogen escape, while higher oxides are decomposed; the resulting brown black solution is heated, and gives off pure nitric oxide. A method of preparing the pure gas directly is to heat ferrous sulphate and sodium nitrate together with somewhat dilute sulphuric acid:

$$\left\{\begin{array}{c} 2NaNO_3 + 2H_2SO_4 = \\ 2NaHSO_4 + 2HNO_3 \\ 2HNO_3 + 6FeSO_4 + 3H_2SO_4 = \\ 3Fe_2(SO_4)_3 + 2NO + 4H_2O \end{array}\right\}$$

(3) NITROGEN TRIOXIDE, N_2O_3 (anhydride of nitrous acid). Not known in pure condition in the gaseous state, for at ordinary temperatures it decomposes nearly completely into nitric oxide and nitrogen peroxide. The blue liquid obtained by condensation of the red fumes evolved from arsenious oxide or starch and nitric acid contains this oxide, but it is not pure, as it undergoes dissociation at very low temperatures. When electric sparks are passed through liquid air a green solid is formed, which remains as a bluish amorphous powder when the air is evaporated. The solid melts at −111° to a deep blue liquid, which easily evolves nitric oxide. Analysis of the solid shows it to be pure nitrogen trioxide. (4) NITROGEN PEROXIDE OR TETROXIDE, NO_2 or N_2O_4. A liquid which boils at 21°. Its colour depends on the temperature. At −10° it is a colourless solid; a little above this it melts to a yellow liquid, becoming red as the temperature rises: above its boiling point it is a red brown gas, which deepens in colour as it is heated, till it appears nearly black (140°). At 140° it has the formula NO_2; at 26·7° it consists of only 20 per cent., NO_2; the rest is N_2O_4. The liquid has the formula N_2O_4, but this dissociates on diluting its chloroform solution. About 620° the gas becomes colourless, forming nitric oxide and oxygen. Anhydrous liquid nitrogen tetroxide is a good solvent for many organic compounds, such as the saturated hydrocarbons, nitro-compounds, many acids; but unsaturated hydrocarbons, hydroxy-compounds, and amines are attacked. Example: Naphthalene gives 1:5 dinitronaphthalene, and phenol gives 2 : 4 dinitrophenol. It is decomposed by water:

$$3NO_2 + H_2O = 2HNO_3 + NO.$$

Phosphorus, charcoal, and potassium will burn in it. When moist it attacks mercury and many other metals forming nitrates. It is usually obtained by heating lead nitrate,

$$Pb(NO_3)_2 = PbO + 2NO_2 + O.$$

The oxygen is separated by passing the gases through a tube immersed in a freezing mixture, from which the oxygen escapes uncondensed. To obtain large quantities, lumps of arsenious oxide are treated with concentrated sulphuric acid and fuming nitric acid, cooling at first, then warming till the reaction stops. The gas is condensed, dehydrated by phosphorus pentoxide, dry oxygen passed through it, and finally it is distilled. (5) NITROGEN PENTOXIDE, N_2O_5 (the anhydride of nitric acid). A white crystalline solid. Melts at 30°; decomposes easily into nitrogen peroxide and oxygen; unites with water to form nitric acid. It is formed by the action of ozone on nitrogen peroxide; by the action of dry chlorine on dry silver nitrate; and by distilling the strongest nitric acid (*q.v.*) with phosphorus pentoxide.

Nitrogen Sulphides (*Chem.*) Two are known: (1) Nitrogen sulphide, N_4S_4, obtained by the action of ammonia on sulphur chloride; forms yellowish red crystals at 135°; it explodes when struck; melts with decomposition at 158°. Heated with carbon disulphide at 100° under pressure, it yields (2) Nitrogen pentasulphide, N_2S_5—a red liquid which does not wet glass; melts at 10°; insoluble in water, soluble in usual organic solvents; decomposed by light into N_4S_4 and S. Boiled with water or alkalis it gives ammonia and sulphur. A trace of alcoholic potash gives a transient violet red coloration (Test).

Nitroglycerine (*Chem.*) $\begin{array}{c} CH_2ONO_2 \\ | \\ CHONO_2 \\ | \\ CH_2ONO_2 \end{array}$. Is not a nitro-compound, but the trinitrate of glycerine. It is a colourless liquid; sp. gr. 1·6; melts about 10°; no smell; sweet taste; used in medicine, as it acts like amyl nitrite; poisonous; insoluble or nearly so in water, but soluble in the usual organic solvents; it can be distilled in steam. On heating, it volatilises even at 100°, and about 180° it explodes; it is also exploded by a blow or by a detonator, especially mercury fulminate. It can be burned without explosion if it is kept warm, but it explodes if

temperature reaches 180°. Nitroglycerine is hydrolysed by alcoholic potash to glycerine and potassium nitrate, thus behaving like a true nitric acid ester. To prepare nitroglycerine on a large scale a spray of pure glycerine is driven by compressed air into a mixture of pure concentrated sulphuric acid and nitric acid; as heat is developed in the process the temperature is carefully regulated by cooling with water which runs in leaden coils in the nitrating vessels. After the operation is over the nitroglycerine collects above the acids, whence it is run into water and thoroughly washed; then with a weak alkaline solution to remove the last traces of acid; finally it is dried by filtering through felt. When in a pure state it can be kept with safety. Nitroglycerine is used in the manufacture of explosives such as dynamite, blasting gelatine, cordite, and others less well known.

Nitrohydrochloric Acid (*Chem.*) Another name for Aqua Regia (*q.v.*)

Nitromuriatic Acid. *See* Aqua Regia.

Nitroso-Compounds (*Chem.*) Compounds of the formula $R-NO$, where R may be a monovalent residue from many different classes of compounds such as hydrocarbons, amines, phenols, nitro-compounds, and many others, *e.g.* nitroso-benzene, C_6H_5NO; dimethylnitrosamine, $(CH_3)_2N.NO$; nitrosophenol,

$$C_6H_4\left\langle{OH \atop NO}\right. ;\ \text{propylpseudonitrol}, (CH_3)_2C\left\langle{NO \atop NO_2}\right. .$$

Nitroso-compounds are obtained in a variety of ways, the following being only a few of them: (1) Oxidation of certain amines by Caro's acid. *See* Sulphur Compounds. The amines which undergo this reaction are those having the nitrogen atom united to a tertiary carbon atom, and aromatic amines such as aniline—

$$(CH_3)_3C.N\left\langle{H \atop H}\right. \rightarrow (CH_3)_3C.N\left\langle{OH \atop H}\right. \rightarrow$$

Tertiarybutylamine.

$$(CH_3)_3C.N=O$$

$$C_6H_5.N\left\langle{H \atop H}\right. \rightarrow C_6H_5N\left\langle{OH \atop H}\right. \rightarrow C_6H_5-N=O$$

Aniline. β-phenylhydroxylamine. Nitrosobenzene.

(2) Nitro-compounds are reduced to hydroxylamines by aluminium amalgam or by electrolysis in acetic acid solution, and the hydroxylamines are oxidised by chromic acid to nitroso-compounds.

$$C_6H_5N\left\langle{\!/\!/O \atop \backslash\backslash O}\right. \rightarrow C_6H_5N\left\langle{OH \atop H}\right. \rightarrow C_6H_5.NO.$$

(3) Action of nitrosylchloride on unsaturated hydrocarbons, *e.g.*

$$(CH_3)_2C=CHCH_3 \xrightarrow{NOCl} {CH_3 \atop CH_3}\!\!>\!C(Cl)-C\left\langle{CH_3 \atop {H \atop NO}}\right.$$

Trimethylethylene. Trimethylethylenenitrosochloride.

This reaction is very important in the chemistry of the Terpenes (*q.v.*) (4) Nitrous acid reacts directly with secondary amines and with nitro-compounds derived from secondary alcohols to form nitrosamines and pseudonitrols respectively:

$$(C_2H_5)_2NH + HO.NO = (C_2H_5)_2N.NO + H_2O$$

$$(CH_3)_2C\left\langle{NO_2 \atop H}\right. + HONO = (CH_3)_2C\left\langle{NO_2 \atop NO}\right. + H_2O$$

This reaction is important in distinguishing secondary from primary and tertiary amines, and secondary from primary and tertiary alcohols. A similar reaction to that with the secondary amines occurs with nitrous acid if one of the alcohol radicals is replaced by an acid radical, *e.g.*

$${CH_3CO \atop C_6H_5}\!\!>\!NH + HO.NO = {CH_3CO \atop C_6H_5}\!\!>\!N.NO + H_2O.$$

Acetanilide. Nitrosoacetanilide.

The fatty *tertiary* amines do not react with nitrous acid; but the aromatic dialkylamines form paranitroso-compounds, *e.g.*

$$N\left\langle{CH_3 \atop {CH_3 \atop C_6H_5}}\right. + HO.NO = N\left\langle{CH_3 \atop {CH_3 \atop C_6H_4.NO}}\right. + H_2O$$

Dimethylaniline. Paranitrosodimethylaniline.

See Gallocyanine *and* Neutral Red. (5) Nitrosophenols result from the action of nitrous acid on phenols, while their ethers are obtained by method (1) from aminophenolethers. The nitroso-compounds are mostly blue or green in colour when in solution or in a state of fusion; but in the solid state they are white. This is due to the fact that they readily polymerise to bimolecular compounds; but the nitroso-compounds of secondary amines are yellow oils. *E.g.* nitrosobenzene is a white solid which melts at 68° to a green liquid; paranitrosophenol is a white solid which decomposes on melting, but is soluble in water or alcohol, forming a green solution; propylpseudonitrol is a white solid which melts at 76° to a blue liquid; it dissolves in cold benzene to a colourless solution, which turns blue slowly on standing and quickly on warming. Many nitroso-compounds easily pass into the so-called iso-nitroso-compounds, which are really oximes. *E.g.*

$${CH_3 \atop {CH_3 \atop Cl}}\!\!>\!C-C\left\langle{CH_3 \atop {H \atop NO}}\right. \rightarrow {CH_3 \atop {CH_3 \atop Cl}}\!\!>\!C-C\left\langle{CH_3 \atop NOH}\right. .$$

Analogous to this transformation of fatty nitroso-compounds is no doubt the tautomeric behaviour of paranitrosophenols as quinonemonoximes.

$$C_6H_4\left\langle{OH \atop NO}\right. \rightarrow C_6H_4\left\langle{\!/\!/O \atop \backslash\backslash NOH}\right.$$

When nitroso-compounds are carefully reduced they yield hydroxylamines; on strong reduction, amines.

$$C_6H_5N=O \rightarrow C_6H_5N\left\langle{OH \atop H}\right. \quad C_6H_5N\left\langle{H \atop H}\right.$$

$$(CH_3)_2N.N=O \rightarrow (CH_3)_2N\ N\left\langle{OH \atop H}\right.$$

$$(CH_3)_2N.N\left\langle{H \atop H}\right.$$

Dimethylhydrazine.

$$\rightarrow (CH_3)_2NH + NH_3$$

Dimethylamine.

On oxidation, nitroso-compounds are in many cases converted into nitro-compounds. *E.g.*

$$(CH_3)_2C\left\langle{NO_2 \atop NO}\right. + O = (CH_3)_2C\left\langle{NO_2 \atop NO_2}\right.$$

ββ-Dinitropropane.

$$C_6H_5NO + O = C_6H_5NO_2$$

Nitrobenzene.

As a common example of the application of nitroso-compounds may be mentioned the laboratory method of separating aniline from methylaniline. The mixture is made into hydrochloride and treated with nitrous acid, when the aniline forms diazobenzenechloride, and the methylaniline forms the nitroso-compound, which can be separated by extraction with ether and methylaniline, obtained from it by reduction with tin and hydrochloric acid. Other examples of their use have been given above. Paranitrosodimethylaniline in particular is used in making dyes.

Nitrosulphonic Acid (*Chem.*) $SO_2\left\langle\begin{matrix}NO_2\\OH\end{matrix}\right.$. Also called Nitrosyl Sulphuric Acid and Leaden Chamber Crystals. Nearly colourless crystalline solid; melts at 30° with decomposition; decomposed by cold water.

$$SO_2\left\langle\begin{matrix}NO_2\\OH\end{matrix}\right. + HOH = SO_2\left\langle\begin{matrix}OH\\OH\end{matrix}\right. + NO.OH$$

At a higher temperature the nitrous acid decomposes, giving its unstable anhydride:

$$2NO.OH = N_2O_3 + H_2O = NO_2 + NO + H_2O.$$

The acid is found in the leaden chambers used in the manufacture of sulphuric acid when steam is deficient. It can be prepared by saturating nitric acid with sulphur dioxide or sulphuric acid with nitrosyl chloride:

$$NO_2.OH + SO_2 = SO_2\left\langle\begin{matrix}NO_2\\OH\end{matrix}\right.$$

$$NOCl + SO_2\left\langle\begin{matrix}OH\\OH\end{matrix}\right. = SO_2\left\langle\begin{matrix}NO_2\\OH\end{matrix}\right. + HCl$$

It is also formed in solution in sulphuric acid in the Gay-Lussac tower, used to absorb the nitrogen peroxide carried away by the escaping leaden chamber gases in the manufacture of sulphuric acid.

$$SO_2\left\langle\begin{matrix}OH\\OH\end{matrix}\right. + 2NO_2 = SO_2\left\langle\begin{matrix}NO_2\\OH\end{matrix}\right. + NO_2OH$$

Nitrosyl Chloride (*Chem.*) ON.Cl. A yellow gas; melts about −60° and boils at −8°. Decomposed by water and by alkalis:

$$ON.Cl + HOH = ClH + ON.OH.$$

Unites with many unsaturated organic compounds to form nitroso-compounds (*q.v.*); *e.g.*

$$(1)\ \begin{matrix}CH_3\\CH_3\end{matrix}\Big> C = C\Big<\begin{matrix}CH_3\\H\end{matrix} + ONCl =$$

Trimethylethylene.

$$\begin{matrix}CH_3\\CH_3\\Cl\end{matrix}\Big> N - N\Big<\begin{matrix}Cl\\H\\NO\end{matrix}$$

Trimethylethylenenitrosochloride.

(2) It unites with many terpenes (*q.v.*) to form terpenenitrosochlorides. Nitrosyl chloride is formed by direct union of nitric oxide and chlorine in the presence of light and a catalytic agent such as carbon; but it is best obtained by warming a mixture of ordinary concentrated nitric and hydrochloric acids (1 vol. to 4 vols.)

$$HO.NO_2 + 3HCl = NOCl + 2H_2O + Cl_2,$$

drying the gases over calcium chloride, and passing them into concentrated sulphuric acid, which only unites with the nitrosyl chloride, which may be obtained from its solution in the acid by warming with dry common salt. The gas is condensed in a tube immersed in a freezing mixture.

Nitrous Acid (*Chem.*) HNO_2 or ON.OH. Unknown in pure condition. It is capable of existing in aqueous solution as a blue liquid at low temperatures; but if the temperature rises it decomposes: $3ON.OH = 2NO + HNO_3 + H_2O$. It is a very important reagent in organic chemistry. *See* DIAZO-REACTIONS *and* NITROSO-COMPOUNDS. When required as a reagent it is generated by acting on a nitrite with an acid. ON.ONa + HCl = ON.OH + NaCl.

Nobling (*Met.*) *See* SHINGLING.

Noblins (*Met.*) The name for blocks of puddled iron 10 or 12 in. square and 1½ to 2½ in. thick, obtained by shingling (*q.v.*) the puddled balls of iron under a helve or hammer. Also called STAMPINGS. *See* STAMPS.

Nocturne (*Paint.*) The term applied to a painting representing some impression of night.

Nodal Points of a Lens (*Light*). These are points defined by the property that if the direction of a ray approaching the lens passes through the first nodal point (when produced), it will emerge as if it came from the second nodal point, and will also be parallel to the incident ray. When the media are the same on both sides of the lens, the nodal points coincide with the Principal Points (*q.v.*)

Node (*Sound.*) A node is a point in a vibrating body (or medium) which remains permanently at rest. In a stretched string, the ends are always nodes; if the string be vibrating in two halves, so as to emit its first overtone, the centre is also a node. In an organ pipe, a closed end is always a node.

Nodes (*Astron.*) The intersection of the orbit of one planetary body with that of another; in particular, the intersection of the moon's orbit with the ecliptic.

Nogging Pieces (*Carp. and Join.*) The horizontal pieces in a quarter or brick nogged partition.

Noil (*Worsted Manufac., etc.*) Short neps of fibres removed in the process of combing. A valuable material, and used in the woollen carding. *See* NEP *and* CARDING.

Noiling Motion (*Worsted Manufac., etc.*) The motion on the combing machine for extracting short fibre. This is done constantly throughout the process of combing.

Nomenclature, Chemical. Names of metals usually end in *-um* or *-ium*, except the names of a few common metals such as iron, copper, tin, etc.; in these cases the Latin names end in *-um*, *e.g.* Ferrum, Cuprum, Stannum. Selenium and Tellurium, which are not true metals, have also this termination; it has been proposed to change their names to Selenion and Tellurion. Compounds of two elements are named by taking the name of one of the elements and putting that first, then altering the termination of the second element to *-ide*, and putting the altered name second; this rule is followed unless the compound has a common name. When the two elements unite in more than one proportion the proportions are indicated by using Latin or Greek numerical prefixes before one or both the names. Examples: Water is sometimes called hydrogen monoxide; a compound containing more oxygen is called hydrogen dioxide or hydrogen peroxide. *See* OXIDES, CHLORIDES, SULPHIDES, NITRIDES, *etc.* Acids have often common names, *e.g.* nitric acid, HNO_3; acetic acid, CH_3COOH. Acids containing only two elements, one of which must be hydrogen, are named as in the case of hydrochloric acid, HCl; hydrobromic acid, HBr, etc. Acids composed of three elements, of which oxygen is one, are named so as to indicate the amounts of oxygen they contain as follows:

Perchloric acid, $HClO_4$. Phosphoric acid, H_3PO_4.
Chloric acid, $HClO_3$. Phosphorous acid, H_3PO_3.
Chlorous acid, $HClO_2$. Hypophosphorus acid, H_3PO_2.
Hypochlorous acid, HClO.
Persulphuric acid, $H_2S_2O_8$. Nitric acid, HNO_3.

Sulphuric acid, H_2SO_4. Nitrous acid, HNO_2.
Sulphurous acid, H_2SO_3. Hyponitrous acid, HNO.
Hyposulphurous acid, H_2SO_2.

Salts derived from these acids are named by stating the metal first, then the acid with its termination changed to *-ate* if it ends in *-ic*, and to *-ite* if it ends in *-ous*. Example :

Nitric acid forms potassium nitrate.
Nitrous acid forms potassium nitrite.
Hyponitrous acid forms potassium hyponitrite.

Some metals combine with the same acid in different proportions: in this case the salt containing the greater proportion of metal is named by changing the termination of the metal to *-ous*. Example :

Mercurous sulphate, Hg_2SO_4.
Mercuric sulphate, $HgSO_4$.
Ferrous nitrate, $Fe(NO_3)_2$.
Ferric nitrate, $Fe(NO_3)_3$.

See also ANHYDRIDE, HYDROXIDE, ACID, SALT, ALKALI. In Organic Chemistry the nomenclature is very complex. Most *classes* of organic compounds are briefly described under the corresponding headings. *See for example* HYDROCARBONS, ALCOHOLS, ALDEHYDES, KETONES, PARAFFINS, ORTHO-, META-, *and* PARA-COMPOUNDS, OXIMES, AMINES, NITRILES. The Geneva or International System of Nomenclature may be briefly described. The paraffin hydrocarbons have names which end in *-ane*. *See* PARAFFINS. When the chain is branched, the longest straight chain is taken as the parent substance and the position of the substituting group is given by a number : if the substituting group has itself substituents which are paraffin residues the termination of the substituent is changed from *-ane* to *-o*, and its position indicated by a number placed as an index above the number of the first substituting group, the numbering starting from the carbon atom attached to the parent chain. Example :

$$\begin{array}{ccccccc} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ CH_3 . & CH_2 . & CH_2 . & CH . & CH_2 . & CH_2 . & CH_3 \\ & & & | & & & \\ & & & 4^1CH . CH_3 & & & \\ & & & | & & & \\ & & & 4^2CH^3 & & & \end{array}$$

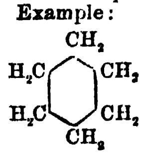
would be called metho-4^1-ethyl-4-heptane. Names of alcohols end in *-ol*, the position of the $-OH$ group being indicated by a number. Example :

$$\begin{array}{ccc} CH_3 & CH_3 & CH_2OH \\ | & | & | \\ CHOH & CHOH & CH_2 \\ | & | & | \\ CH_3 & CH_2OH & CH_2OH \end{array}$$

Propane-2-ol. Propane-1 : 2-diol. Propane-1 : 1^1-diol.

Aldehydes have names ending in *-al*.
Ketones have names ending in *-one*.

Amines are named as amino-substitution products of the hydrocarbons; saturated ring hydrocarbons are named after the corresponding paraffins with the prefix cyclo. Example:

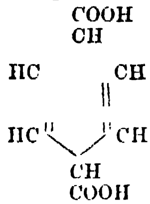


Cyclohexane.

Unsaturated hydrocarbons containing ethylene linkings have names ending in *-ene*, and the number of double linkings is indicated by a numerical prefix, the positions of the double bindings being indicated by numbers placed after the temination *-ene*. Example : Dimethyl, 2 : 6 ; heptadiene, 4 : 6.

$$\begin{array}{ccccccccccccc} 1 & & 2 & & 3 & & 4 & & 5 & & 6 & & 7 \\ CH_3 . & & CH & - & CH_2 & - & CH & = & CH & - & C & = & CH_2 . \\ & & | & & & & & & & & | & & \\ & & CH_3 & & & & & & & & CH_3 & & \end{array}$$

Acids have names ending in *-oic* and derived from the corresponding hydrocarbon. Example : Formic acid, HCOOH, would be called methanoic acid. An important method of indicating double linkings in the benzene ring due to von Baeyer must be mentioned. The Greek letter Δ indicates a double binding, and, starting from position 1 in the ring, the position of the double binding is indicated by a number placed after the letter, the number indicating the first carbon atom reached, bearing the double linking. Example :

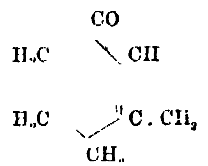


Δ 2 : 5 dihydroterephthalic acid.

General examples : Triacetylmethylol-2-nitro-2-propandiol-1-3.

$$\begin{array}{c} CH_2O . COCH_3 \\ | \\ O_2N . C . CH_2O . COCH_3 \\ | \\ CH_2O . COCH_3 \end{array}$$

3-methyl-Δ^2-keto-R-hexene. (R stands for ring or cyclo).



Nominal Horse Power (*Eng.*) The amount of power which an engine is declared by the designers or manufacturers to develop. *See* INDICATORS (*Eng.*)

Non (*Music*). Not.

Non-Conductor (*Elect.*) *See* INSULATING MATERIAL, *etc.*

Nonet (*Music*). A composition for nine voices or instruments.

Non-Inductive Circuit (*Elect.*) An electric circuit which possesses a very small amount of inductance (*q.v.*); no circuits are absolutely non-inductive, but the term is applied to those in which the inductance is negligible.

Non-Metals (*Chem.*) The common non-metals are : Hydrogen, Fluorine, Nitrogen, Oxygen, Chlorine, Bromine, Boron, Carbon, Silicon, Phosphorus, Sulphur, Arsenic, Iodine. Much less common is Selenium. Tellurium may be classed as a metalloid ; that is, it has partly metallic and partly non-metallic properties. The first five are gases, bromine is a liquid, the rest are solids. They all form gaseous hydrides ; that is, compounds with hydrogen. They are bad conductors of electricity with the exception of carbon ; they are bad conductors of heat and not malleable or ductile. The majority form chlorides, which are decomposed by water giving acids. They

all combine with oxygen except fluorine, and the great majority of these oxides give acids with water; water (*q.v.*) is both an acid and an alkali. Nitric oxide and carbon monoxide have no acid properties. The inert gases, Argon, Helium, etc., must be regarded as forming a class by themselves, as, on account of their wanting chemical activity, they cannot be classed either as metals or non-metals.

Nonpareil (*Typog.*) Type between emerald and pearl. *See* TYPE.

Non-Pathogenic Bacteria. *See* BACTERIA.

Non-Slipping Tyres (*Cycles, Motors*). *See* TYRES.

Non-Slip Stone. *See* ARTIFICIAL STONE.

Noon (*Astron.*) The moment of time when the sun is on the meridian. The astronomical day commences at noon.

Nopalea (*Botany*). A plant of great interest (*Nopalea coccinellifera*; order, *Cactaceæ*). It is cultivated principally in Mexico and other warm parts of America, and in addition to producing an edible fruit is used for rearing cochineal insects.

Nordhausen Sulphuric Acid (*Chem.*) *See under* SULPHUR COMPOUNDS.

Normal (*Math.*) The NORMAL to a curve is a line drawn from a point on the curve perpendicular to the TANGENT (*q.v.*) to the curve at the same point.

—— (*Min.*) The Normal of a crystal face is a line through the origin, perpendicular to the plane of the face.

Normal Salt (*Chem.*) *See* SALTS.

Normal Solution (*Chem.*) *See* VOLUMETRIC ANALYSIS.

Norman Architecture. The architecture of England between the years 1066 and 1189 A.D. It is also known as English Romanesque. The principal features of this style are as follows:—*Mouldings:* Simple, bold, not undercut, and frequently enriched. *See* BEAK HEAD, BILLET, CHAIN, *and* STAR MOULDING, CHEVRON. *Capitals:* Usually of the cushion type, and frequently carved. *See* CUSHION CAPITAL. *Piers:* Heavy square or cylindrical masses at first, but as the style developed the piers became lighter, and banded shafts were used. *Arches:* Semicircular, frequently richly moulded. *Doorways:* These are usually the most ornate features in the design, the arches being richly moulded, and clustered shafts used in the jambs. *Windows:* Semicircular headed, and frequently arranged in pairs with a shaft between. *Vaults:* Barrel vaults, groined vaults, and ribbed vaults were used, stilted and horseshoe arches being used in oblong bays. *Carving:* The carving was at first very crude and shallow, being executed with the axe, but the chisel work of the later period is very fine, though often confined to the repetition of simple ornaments.

Norte (*Meteorol.*) *See* NORTHER.

North *or* **North-Seeking Pole** (*Elect.*) That pole of a magnet which tends to turn towards the north when the magnet is freely suspended.

Norther *or* **Norte** (*Meteorol.*) A cold dry north or north-west wind that occurs in the United States. In the southern parts it is called by this name, but in the north it is termed "blizzard."

——, **Black** (*Meteorol.*) A cold wind, so called by the Greeks.

Norwich Crag (*Geol.*) *See* CRAG.

Nose (*Glass Manufac.*) That end of the blowing iron upon which the molten glass is gathered.

Nosean (*Min.*) A sodium and aluminium silicate and sodium sulphate, $Na_4(NaSO_4 . Al)Al_2Si_3O_{12}$. Cubic; greyish or brown. It is of some interest as a rock forming mineral, occurring in some phonolites.

Nosing (*Build.*) The projecting edge of a moulding; the rounded projection of a window board, stair tread, etc.

Nosing Motion (*Cotton Spinning*). An attachment to the mule quadrant for determining the conical shape or chase of cop by regulating the speed at which the spun thread is wound round the spindle during winding on.

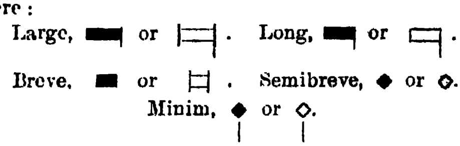
Notch Board (*Carp. and Joinery*). *See* CUT STRING.

—— (*Civil Eng., etc.*) A vertical barrier placed across a stream, and provided with a V-shaped notch through which the water flows. By measuring the breadth and depth of the part of the notch occupied by the water, the amount passing over in any given time may be found.

Notch Head (*Architect.*) *See* MASK.

Notching *or* **Linking Up** (*Eng.*) *See* LINK MOTION.

Notes (*Music*). Marks indicating sound. They are of different shapes, as follows:—Breve, 𝅜; semibreve, 𝅝; minim, 𝅗𝅥; crotchet, 𝅘𝅥; quaver, 𝅘𝅥𝅮; semiquaver, 𝅘𝅥𝅯; demisemiquaver, 𝅘𝅥𝅰; hemidemisemiquaver, 𝅘𝅥𝅱. Each of these is one half the value of the preceding note. In older music the notes were:



the Large being equal to four Breves or two Longs. This system of notation was formulated by Franco of Cologne, in the latter half of the eleventh century, according to one writer, and about 1200 according to another authority. *See also* PLAIN SONG.

—— (*Sound*). A note is, strictly speaking, a sound whose frequency of vibration, and therefore its pitch, are constant.

—— (*Typog.*) These are usually classed as: (*a*) footnotes; (*b*) marginal or side notes; (*c*) cut in notes; (*d*) shoulder notes. A footnote may be described as a passage explanatory of the text, and is set apart from it in a type two sizes smaller in body. Marginal notes, as their name implies, are placed on the margin of the page—usually outside and close to the reference in the text. Cut in notes are let into the square of the page, some of the lines of text being shortened for the purpose. These are generally placed on the folio side of the page. Shoulder notes refer to dates or volumes. Footnotes and, occasionally, marginal notes are indicated by reference marks, which are—the asterisk (*), the dagger (†), the double dagger (‡), the section (§), the parallel (‖) and the para-

graph (¶), used in the order here given. Two of each sign are used when the number of references exceed six. Another and older method is to use "superior" figures (1), (2), etc. Again, literal or letter references are used; these also are "superior," and may be either Roman or italic. When notes to a work are exceptionally numerous, or when for purposes of chronological sequence it is desirable to avoid division, they are sometimes placed under a distinctive heading at the end in the form of an addendum.

Nottingham White (*Dec.*) A term now nearly obsolete; formerly applied to a variety of reduced (*i.e.* adulterated) white lead.

Nourishing. *See* FAT LIQUORING.

Nova (*Astron.*) A new star.

Nowed (*Her.*) Knotted or twisted. Serpents are sometimes represented in this attitude as charges.

Noyau. A liqueur flavoured either with peach stones, oil of bitter almonds, the kernel of the Mahaleb cherry, or sometimes with essence of mirbane.

Nozzle (*Eng., etc.*) The jet or part of a pipe or tube containing the orifice.

N.P., *or* **New Par** (*Typog.*) Signifies commence a new paragraph. *See* PROOF CORRECTIONS.

Nucleic Acids (*Chem.*) White amorphous powders of unknown constitution; sparingly soluble in cold water, easily soluble in hot water; easily soluble in alkalis with which they form salts; their solutions are dextrorotatory; they unite with albumins. They are derived from the nucleo-proteids. *See* PROTEIDS. They yield on decomposition many important compounds of known composition, *viz.* (1) Phosphoric acid. (2) Pyrimidine derivatives. *See* PYRIMIDINES. (3) Purine bases. *See* PURINE. (4) Pentoses (*q.v.*) (5) Lævulinic acid (*q.v.*)

Nucleus (*Astron.*) A term used to express the innermost portion of a sun spot, comet, nebula, etc.

—— (*Botany and Zool.*) A protoplasmic body found in animal and plant cells. It is essential for carrying on the vital activities of the cell, and is especially concerned in cell division.

Nude (*Art*). A term applied to an undraped figure or statue; also to a study of the figure from the naked living model.

Null *or* **Zero Methods** (*Elect.*) A class of electrical measurements in which two quantities are compared by reducing one to equality with the other, the absence of any movement, deflection, etc., of the indicating instrument being taken as proof that such equality has been obtained. The measurement of resistance by Wheatstone's Bridge (*q.v.*) is an example of this method.

Numerals (*Typog.*) Letters or figures used for the purpose of indicating numbers. *Roman* numerals are represented by the letters I, V, X, L, C, D, M. I signifies one, V five, X ten, L fifty, C one hundred, D five hundred, M one thousand. These are placed in certain order to represent varying numbers, and are duplicated as necessary. When the lesser is placed before the greater, the lesser is deducted from the greater; thus, IV signifies one less than five, *i.e.* four. Lesser numbers placed after the greater are added. Capital, small capital, lower case, and italic letters are used in different circumstances. The *Arabic* numerals are expressed by the figures 1 to 0.

Nut (*Botany*). A one seeded, dry, indehiscent fruit, having a hard, woody coat and bearing persistent bracts, which in the oak (acorn) form a cup at the base of the nut. The Brazil "nut" is a woody seed; the cocoa- "nut" is a fibrous drupe.

—— (*Eng.*) The loose head of a bolt containing the hollow (or female) screw.

Nutation (*Astron.*) A slight motion of the pole of the Equator alternately towards and away from the pole of the ecliptic: a "nodding" of the pole. Has a period of nineteen years.

Nut Brown Colour (*Eng.*) The usual name for the brownish tint produced in tempering steel by heating it up to about 550° F. *See* TEMPERING.

Nutmeg (*Botany*). The nutmeg is the seed of the plant *Myristica fragrans* (order, *Myristicaceæ*), growing in the Moluccas, the islands of the Indian Ocean, the West Indies, etc. The fruit is prepared for export by drying over a slow fire. "Mace" is the bleached aril surrounding the seed.

Nut Oil. *See* WALNUT OIL.

Nutria (*Zool.*) The trade name for the fur of the coypu (*Myopotamus coypus*), an Argentine aquatic rodent. The skins of this animal are largely imported into Europe.

Nut Wrench (*Eng.*) A SPANNER (*q.v.*)

Nux Vomica (*Botany*). The dried seeds of *Strychnos nux vomica* (order, *Loganiaceæ*), a tree found throughout Southern and Eastern Asia and the north of Australia, notably in Ceylon. The extract and tincture are used in medicine.

Ω (*Elect.*) A symbol sometimes used for MEGOHM (*q.v.*)

ω (*Elect.*) A symbol for OHM (*q.v.*)

O (*Chem.*) The symbol for OXYGEN (*q.v.*)

—— (*Music*). Or.

Oak (*Botany*). Apart from its timber, the oak (*Quercus*, a genus of the order *Cupuliferæ*) yields many useful products. *Q. suber* provides the common cork, while the bark of *Q. robur* is used in tanning. *See also* VALONIA, QUERCITRON, *and* WOODS.

Oat (*Botany*). The cultivated cereal *Avena sativa* (order, *Gramineæ*) is probably a domesticated form of the wild oat (*A. fatua*).

Oatmeal (*Foods*). When the husks are removed from oats the grains are known as GROATS or GRITS, and these groats, when finely ground, constitute oatmeal. Oats rank second to wheat in point of nutrition, containing large amounts of proteid and fat, especially the latter. Oatmeal cannot be made into bread, owing to the absence of gluten; it is, however, made into thin cakes (oatcakes) by mixing into a paste with water, and then baking on an iron plate.

Obbligato (*Music*). A "necessary" part to a musical composition which cannot be dispensed with.

Obelisk. A column with a square base and rectangular in form. It diminishes in size towards the top, and usually terminates in a short pyramid. Egyptian obelisks are generally monoliths, *e.g.* Cleopatra's Needle on the Thames Embankment.

Oberon (*Astron.*) The outermost satellite of Uranus.

Oberwerke (*Music*). The German name for swell organ. *See* ORGAN *under* MUSICAL INSTRUMENTS.

Object Glass (*Light*). The lens in a telescope through which light enters the instrument; it produces a real image of the object viewed.

Objective (*Light*). In a microscope the lens or system of lenses through which the light enters the instrument; its function is to produce a real image of the object viewed. In an optical lantern the objective is the system of lenses which produces the magnified image of an illuminated slide (or other object) on the screen.

Objective Grating (*Astron.*) A diffraction grating placed before the object glass of a telescope for the observation of spectra.

Objective Prism (*Astron.*) A prism placed before the object glass of a telescope for the observation of spectra.

Oblateness (*Astron.*) The term applied to a form having more resemblance to an ellipse than a circle. The form of the Earth is characterised by its "ellipticity" or "oblateness."

Oblique Tenon (*Carp. and Join.*) The joint used when the pieces to be joined form an acute angle.

Obliquity of Connecting Rod (*Eng.*) The angle made by the connecting rod with the axis of the cylinder; it is greatest when the crank is at right angles to the rod. The obliquity affects the time at which the ports open and shut; it should be reduced as much as possible by using a long connecting rod.

Obliquity of the Ecliptic (*Astron.*) The angle between the ecliptic and the celestial equator. It is about $23\frac{1}{2}°$.

Oboe (*Music*). A reed stop on an organ. *See also* MUSICAL INSTRUMENTS—WIND.

Oboe d'Amour (*Music*). *See* MUSICAL INSTRUMENTS—WIND.

Oboe di Caccia (*Music*). *See* MUSICAL INSTRUMENTS—WIND.

—— *See* MUSICAL INSTRUMENTS—WIND (WOOD).

Obsidian (*Geol.*) The native glassy form of the volcanic rock known as Liparite, which is identical in chemical composition with granite. What is known as pumicestone is the same substance as obsidian, and owes its frothy condition to the fact that the fluid rock from which obsidian has cooled was heavily charged with steam and other gases, whose endeavours to escape have given rise to abundant cavities as the rock cooled.

Obtuse Angle. One greater than a right angle (90°).

Obverse (*Coins*). The side of a coin, medal, etc., on which the principal design, generally a head, appears. *Cf.* REVERSE.

Ocarina (*Music*). A terracotta instrument varying in size, and having finger holes pierced in the side. Its tone is rather sweet, but hollow.

Occlusion (*Chem.*) A name given by Graham originally to the property which platinum possesses of absorbing hydrogen when heated to redness in the gas, and of retaining it for an indefinite time at a lower temperature. Red-hot platinum absorbs 3·8 times its volume of hydrogen, and at 100° 0·76 times its volume. Palladium in the form of wire occludes 935 times its volume at a red heat, and 376 times its volume at the ordinary temperature. It increases in volume during the process. Copper, gold, silver, and iron all absorb small quantities of hydrogen. The state of the hydrogen when occluded by metals is uncertain; it has been suggested that it forms "unstable, easily dissociating compounds." Whatever its state, the hydrogen in palladium is capable of readily entering into reaction; it unites with oxygen to form water, reduces ferric and mercuric salts to "-ous" salts, and unites with iodine to form hydriodic acid.

Occultation (*Astron.*) The passage of the moon's disc across a star or planet.

Ochre (*Dec.*) A valuable group of natural pigments found in many parts of the world, and varying in colour from light to reddish brown yellow. The colouring matter is due to the presence of hydrous peroxide of iron, but analysis tells little as to the quality of ochres. Tone or colour is of great importance, as well as fineness of grinding. Crude ochres are prepared for painters' use by the process of levigation, after having been ground, if the hardness of the ochre renders this necessary. The pigment is dried at a low temperature, so as not to change the colour, and is then usually ground in oil. Sometimes the golden yellow ochres are "doctored" by the addition of a little chrome yellow.

Ochrea (*Botany*). The name given to the pair of coherent stipules forming a sheath round the stem, as in the dock family (*Polygonaceæ*).

Octagon. A plane rectilinear figure bounded by eight equal sides.

Octahedrite (*Min.*) A synonym for ANATASE (*q.v.*)

Octahedron. A solid bounded by eight planes; in a Regular Octahedron, the faces are equilateral triangles.

Octant. A SECTOR (*q.v.*) whose area is equal to one-eighth of the area of the circle; the radii bounding it make an angle of 45° with each other.

Octastyle (*Architect.*) A term used to denote a temple which has eight columns in the front row. *See* HEXASTYLE, PENTASTYLE, DISTYLE, *and* DECASTYLE.

Octave (*Music*). (1) The eighth note above, and bearing the same alphabetical name. It is the first of the harmonic series of sounds (*q.v.*), the vibrations being double the number of the octave beneath it. *See* INTERVALS. (2) Another name for the stop called "Principal" on organs. *See* ORGAN *under* MUSICAL INSTRUMENTS.

—— (*Sound*). The interval between two notes one of which has twice the frequency of the other.

Octave Flute *or* **Ottavino.** The name sometimes given to the piccolo.

Octavo (*Print.*) A leaf forming one-eighth of a sheet when folded for binding is said to be octavo size. The sheet thus makes 16 pages. Abbreviation, 8vo.

Octet (*Music*). A composition for eight voices or instruments.

Octodecimo (*Print.*) A leaf forming one-eighteenth of a sheet when folded for binding is said to be octodecimo in size. The sheet thus makes 36 pages. Abbreviation, 18mo.

Ocular (*Astron.*) *See* EYEPIECE.

Oculus (*Architect.*) (1) A large circular window in the centre of the west front of a church. This is a common feature in Continental churches, but is rarely met with in England. (2) A similar window or opening in the centre of a dome—as, for instance, the unglazed circular opening 27 in. diameter in the crown of the dome of the Pantheon at Rome.

Odeum (*Architect.*) A roofed building used by the ancient Greeks and Romans for musical performances. The name is sometimes applied to modern buildings used for similar purposes.

Odontograph (*Eng.*) A scale used in drawing the forms of the teeth of wheels.

Œnochoe (*Archæol.*) A small jug or vase, sometimes with a strainer in the neck, used for transferring the wine from the crater (*q.v.*) to the drinking-cup.

Œsophagus (*Zool.*) The œsophagus or gullet forms a straight tube leading from the pharynx to the stomach.

Off Cut (*Print.*) (1) The part of a sheet that is cut off to make it the proper size. (2) The part of a printed sheet cut off and folded separately for insertion in the larger portion, *e.g.* in the case of a duodecimo sheet.

Offensive Trades (*Hygiene*). The Public Health Act, 1875, sec. 112, specifies the following as offensive trades: Blood boiler, bone boiler, fellmonger, soap boiler, tallow melter, tripe boiler. The model byelaws of the Local Government Board specify, in addition to the above, the trades of blood drier, leather dresser, tanner, fat melter and extractor, glue maker, and size maker. The Public Health (London) Act, 1891, adds to these: manure manufacturer, knacker, and slaughterer of horses. As to what constitutes an offensive trade other than those specified, it is held that the business, in addition to being proved noxious, must be of the same nature as those specified, and must deal with animal matters in some form. Under penalty of a fine of £50, with a daily continuing penalty of £50, it is absolutely prohibited to establish anew in London the trade of blood boiler, bone boiler, manure manufacturer, soap boiler, tallow melter, or knacker; and without the consent of the London County Council, that of fellmonger, tripe boiler, or horse slaughterer. The business of soap boiling may be established anew with the sanction of the London County Council, provided that no animal oils or fats other than olein are used in the manufacture. The chief nuisances arise from the improper storage of the materials used and the offensive vapours given off during the process of manufacture.

Official (*Pharmacy*). Drugs are said to be "official" if they are included in the British Pharmacopœia, a list prepared and published by the General Medical Council acting under the authority of Parliament. A similar list is issued in most other countries. The name assigned to a substance in this list is its "official name."

Officinal (*Pharmacy*). The term applied to drugs kept and sold by druggists or apothecaries for medicinal use. *See* OFFICIAL.

Offing *or* Visible Horizon (*Astron.*) The bounding line of the portion of the earth visible to an observer whose eye is some distance above the surface. If R = radius of the earth, h the height of the eye above the surface, then the distance of the offing is (approximately) $\sqrt{\frac{2h}{R}}$

— **Distance of.** *See* OFFING.

Offset (*Botany*) A short stout shoot developed from the parent plant as a means of vegetative reproduction.

—— (*Build.*) A horizontal or inclined ledge, occurring at a change in thickness of a wall, buttress, etc.

Offset (*Elect. Eng.*) A subsidiary wire or cable leading from a main to a point where current is required.

—— (*Surveying*). A distance measured transversely from a point in a station line (usually at right angles to the latter) to some other point or object the position of which relative to the line is to be ascertained.

Ogee (*Architect.*) (1) A compound moulding formed by the conjunction of a cavetto and an ovolo. (2) A form of arch having each of its sides shaped similarly to a cyma-recta. The ogee arch was frequently used in the Decorated period of Gothic architecture. *See* CYMA.

Ogival (*Architect.*) A French term signifying Gothic. *See* OGIVE.

Ogive (*Architect.*) A French term used somewhat loosely, denoting the following: (1) A pointed arch. (2) A diagonal rib or arch of a Gothic vault. (3) An ogee (*q.v.*) *See* OGIVAL.

Ohm (*Elect.*) The practical unit of RESISTANCE (*q.v.*) It is equal to the resistance of a uniform column of mercury 106·3 cm. long and 14·4521 grams in weight at 0°C. For the purposes of legal definition it is the resistance of a certain standard coil at a temperature of 15·4°C.

Ohmic (*Elect.*) Due to, or relating to, RESISTANCE (*q.v.*) Thus OHMIC LOSS is the energy lost in a circuit through the resistance of the conductors.

Ohm Meter (*Elect. Eng.*) An instrument for the commercial measurement of resistance by a simple process.

Ohm's Law (*Elect.*) In any circuit the ratio of a uniform electromotive force to the current which it produces is a constant; this constant is termed the Resistance of the circuit. If C be the current, R the resistance, and E the electromotive force, then C is proportional to $\frac{E}{R}$. If the current be in ampères, the resistance in ohms, and the electromotive force in volts, then $C = \frac{E}{R}$.

Oil Coil (*Elect.*) (1) A transformer which is oil cooled. (2) A TESLA COIL (*q.v.*)

Oil Cooling (*Elect. Eng.*) Enclosing a transformer in a bath or tank containing oil, in order to aid the dissipation of heat due to the currents.

Oiled Paper (*Paper Manufac.*) The paper used for copying books consists of ordinary paper brushed over with boiled linseed oil.

Oil Engine. An engine in which the source of energy is the combustion within the cylinder of a gaseous charge, derived from the vaporisation of a suitable oil. Strictly speaking, this definition includes all the types of engine used in motor cars, cycles, and boats; but it is convenient to make a distinction between those engines using a very volatile oil (petrol, motor spirit, etc.) and those using a heavy oil, such as ordinary Petroleum. To the latter class the term Oil Engine is most commonly applied. The design commonly follows that of a Gas Engine (*q.v.*), with the addition of a tank or reservoir to contain a supply of oil; a Vaporiser or Carburetter, by which the oil is converted into vapour, and the necessary pumps, valves, and tubes by which the supply of oil to the vaporiser is maintained. Oil Engines of modern type differ

chiefly in the nature of the vaporising arrangements, and are usually divided into four main classes: I. The explosive mixture is formed in a large chamber, into which the oil is injected by a spraying nozzle. The vapour mixes with the whole of the air necessary for combustion while in this chamber, and the mixture is drawn into the cylinder as required. The chief objection to this type is the presence of a large volume of explosive gas in the vaporiser. II. The oil is vaporised in a small chamber along with a little air; the remainder of the air required for combustion enters the cylinder through a separate valve. III. The oil is vaporised in a small chamber, through which the whole air supply is also drawn. IV. The oil is vaporised in the combustion chamber itself, which is an extension of the cylinder; air enters through a separate valve. In order to start the engine, the combustion chamber is heated by a lamp; when the engine is running, the necessary temperature is maintained by the explosions. The Hornsby Ackroyd engine is typical of Class IV. A suitable quantity of oil is forced into the combustion chamber and rapidly vaporised; owing to the absence of fresh air, the vapour does not ignite at this stage. The forward stroke of the piston then draws in a supply of air; the return stroke compresses the mixture, raising its temperature by the compression, and ignition occurs spontaneously, just as the piston commences the next forward stroke. The timing of the ignition is effected by varying the amount of compression, *i.e.* by altering the volume of the clearance space. Thus no ignition tube, sparking plug, or other special device for firing the charge is required. The governing of the engine is effected by regulating the supply of oil which enters the combustion chamber. An oil engine requires no permanent supply of gas and no fixed pipes or connections: its fuel is cheap and portable, and the engine can be set up in places where gas is unobtainable and coal is scarce or difficult to transport. Extensive trials have shown that the consumption of oil in a good engine may be as low as ·75 lb. per indicated horse power hour.

Oil Feed (*Eng., etc.*) Any apparatus used for supplying oil regularly to a moving part of a machine.

Oil Fuel (*Eng.*) The methods of using oil as fuel or the source of energy may be divided as follows: I. INTERNAL COMBUSTION: The oil is vaporised and forms an explosive mixture in the cylinder of an engine, as described under OIL ENGINE and PETROL ENGINE (*q.v.*) II. EXTERNAL COMBUSTION: The oil is burnt in the firebox or furnace of a boiler in order to generate steam. The oil may be vaporised in a separate chamber, and burnt with a suitable air supply at the mouth of a large burner; this method is used in the boilers of steam motor cars and certain other small boilers. In larger boilers, the oil is sprayed direct into the firebox along with an air supply, sometimes supplemented by a jet of steam. The firebox should be provided with either a lining or a bridge of firebrick, to prevent the flame from playing directly on the metal surfaces. The great advantages of oil fuel are the reduction of space for storage, saving of labour in handling the fuel and in stoking, rapidity with which steam can be got up, and the ease with which the rate of combustion can be controlled. It is thus very suitable for use in steam vessels, especially battleships. Oil fuel used for external combustion is, however, dearer than coal.

Oil Hardening (*Eng.*) Steel is sometimes hardened by heating to redness and plunging into oil; this cools it less rapidly than water would do, the result being that it is less brittle.

Oiling (*Woollen Manufac.*) The application of oil to wool prior to blending and carding. This causes the fibres to glide very readily over each other and to be easier of separation, and yet imparts an artificial degree of adhesiveness.

Oiling Motion (*Woollen Manufac.*) A mechanical method of oiling the wool as it passes over the feed sheet of the Fearnought or the Teazer. It sprinkles the wool with a regular quantity of the oiling composition.

Oil of Mustard (*Chem.*) *See* MUSTARD OILS.

Oil of Turpentine (*Dec.*) *See* TURPENTINE.

Oil of Vitriol (*Chem.*) A common name for sulphuric acid (*q.v.*) *See* SULPHURIC ACID.

Oil Paint (*Dec.*) Paint mixed with oil, usually linseed, in contradistinction to water paints and distemper, in which water is employed as a vehicle instead of oil.

Oil Painting. *See* PAINTING (METHODS) *and* HOUSE PAINTING.

Oil Pump (*Eng.*) A small pump either driven by hand or working automatically; used to force oil into bearings or other moving parts of machinery.

Oils. Oils and fats are obtained from nearly every subdivision of the vegetable and animal kingdoms, while the earth yields a very similar product in so-called mineral oil (*see* PETROLEUM), which was doubtless, originally, of organic origin. No precise classification of oils is possible, and the plan usually followed is to arrange them according to the properties they possess; for instance, vegetable oils being divided into drying, semi-drying, and non-drying oils. The animal oils are more usually divided according to their source of production, viz. fish oils, liver oils, and blubber oils, beef and mutton tallows, bone fat, horse fat, etc. A further classification deals with the oils according to their particular uses and the treatment necessary to fit them for the purpose in view. The difference between an oil and a fat depends only upon temperature; thus butter, which is considered a fat in this country, might also be classified as an oil in a very hot climate. Nearly all vegetable oils are extracted from the seed, either by (*a*) expression or (*b*) volatile solvents. Linseed oil is the vegetable oil which is most largely produced in this country, the value of the linseed or flax seed imported in one year amounting in round figures to £4,500,000 in value. The value of cotton seed imported amounts to nearly £3,500,000, and the quantity is increasing.

Although the treatment of the oil seeds and the machinery employed varies with the particular kind of seed to be treated, the operations are in many respects similar. LINSEED is now usually taken up from barges or vessels brought alongside the wharves to the top of the mill by means of portable elevators or suction pipes. Here it is conveyed to any part of the building by means of travelling bands and a series of shoots leading from floor to floor, and is ultimately conveyed to the milling room, which is usually on the ground floor. The seed as received from abroad is often mixed with various other seeds, stones, dust, and foreign material. When a better

class oil is required the linseed, before reaching the milling room, is passed through a cleaning machine worked in conjunction with a fan, by which means dust and foreign seeds are extracted. Magnets are sometimes used in addition to take out nails and pieces of metal which may have accidentally become mixed with the seed. The first operation in the milling room is to grind the seeds into meal in an edge runner, or between rollers of an Anglo-American five roller machine. It is then usually conveyed to a kettle, heated by steam and partly cooked, this having the effect of increasing the yield of oil, or rather of rendering it more fluid and easy to extract. Beneath the kettle is a measuring box, which, when full, is drawn out, the meal dropping on to a press cloth and being then lightly pressed, so that it may be taken out in a fairly solid form for conveyance to the hydraulic press. The solid cake of meal, with the press cloth, is then placed between two iron plates, and further cakes and plates are built up to the extent of usually about sixteen. Each plate is engraved with the name or device of the manufacturers. The hydraulic press having been started, the oil is gradually pressed out, and runs off into a tank below, whence it is afterwards pumped to the refinery, or in some cases sent to a firm who make a business of refining. The cake or residue of the linseed, while still warm, is trimmed in a special paring machine, and forms valuable feeding stuff for cattle, owing to the oil contained in it. In some cases where the residual cake is not to be used, such as in the case of castor oil seeds, a second pressing is given, the first cake being broken or ground up for the purpose. The process described is substantially that followed in the case of most seeds. The recovery of oil by means of solvents is carried on principally in connection with rape seed and castor seed; the solvent used is usually petroleum ether or carbon bisulphide. Two types of apparatus are in use, one termed the "cold" process, and the other the "hot." In the former a series of vessels are so arranged that the solvent percolates from end to end in such a manner that the particular vessel which receives the refuse meal that has been acted upon is the one which, when emptied, is ready to be recharged. The mixture of oil and solvent being withdrawn, the latter is driven off by means of heat, the vapour being condensed in a coil so that it may be used over and over again. The hot process is objectionable from the risk of fire. Linseed oil is the principal PAINT OIL (*q.v.*) The preparation of COTTON SEED OIL is in many respects similar to that of linseed oil; the cotton husks being expressed, the product is used very largely for food. It is estimated that 9,000,000 gallons are employed in one year for making compound lard. OLIVE OIL is obtained from the fruit of olives after the kernels have been removed. In the best grades the fruit when ripe is picked by hand, usually in the months of October and November. The fruit is crushed, and the pulp placed in rush baskets with a small opening at the top. These baskets are placed one on top of the other in a press worked by hand. The oil is thus expressed, and runs into a vessel below, which is partly filled with water, in order that the impurities contained in the oil may be deposited and the oil collect on the surface. The pulp is subsequently crushed several times, thus giving various grades of oil, of which there are a large number, depending not only upon the method of preparation, but also on the degree of ripeness of the fruit, the variety of the tree from which the olives are obtained, and other circumstances. Olive oil is chiefly employed for alimental purposes; the inferior qualities are frequently employed for soapmaking, and also as lubricants (*q.v.*) Olive oil is often adulterated with cotton seed oil and oil from various vegetable sources. The specific gravity of olive oil at 15° C. is 0·9178; this is for best or virgin oil; that of Gallipoli oil is 0·9196.

DRYING OILS are those which, when exposed to the air, combine with oxygen and become hard. Non-drying oils when so exposed do not dry, but become rancid, and in many cases undergo decomposition. The principal drying oils, in addition to linseed oil, are the oils derived from hemp seed, poppy seed, walnuts, castor seed, sunflower seed and grape seed. There are many other drying oils, such as garden cress seed oil, hickory oil, melon seed oil, pumpkin seed oil, which are not regarded as commercial products. HEMP SEED OIL is sometimes used in the manufacture of colours and varnishes, being then usually mixed with linseed oil. It is also employed for the same uses as olive oil. POPPY SEED OIL is somewhat important, because of its light colour. It is largely employed abroad for grinding white paints such as zinc oxide, the absence of colour being valued where it is desired to maintain the purity of tint. Poppy oil in this country is chiefly used for artists' colours; walnut oil is also used for artists' colours. *See also* WALNUT OIL, CASTOR OIL, POPPY SEED OIL.

The principal NON-DRYING VEGETABLE OILS are cotton seed oil (*q.v.*), ground nut oil (arachis), hazel nut oil, maize oil, almond oil, palm oil, cocoanut oil, and olive oil. The following oils are also produced in various parts of the world in more or less large quantities: plum kernel oil, sesame oil, mustard oil, horse chestnut oil, peach oil, quince oil, radish seed oil, rice oil, cherry kernel oil, linden wood oil, tea seed oil, beech nut oil, acorn oil, and croton oil.

ANIMAL FATS and oils are produced in very large quantities in a variety of different ways, having for their object the same end as in the case of vegetable oils, namely, the separation of the oil from the extraneous material. In many cases the process consists principally of boiling in closed vessels, and drawing off the oil so obtained. The animal kingdom contains oil almost universally, and very little of it is wasted. The most familiar example of the production of fat or tallow from freshly killed cattle and sheep is done in each of the large towns, usually by the biggest firms of soapmakers, who collect the waste fat at frequent intervals, and in some cases have offices and depôts established in connection with the meat markets or slaughtering houses. In such cases the scrap fat is boiled down the same day as it is collected, and in this case it is usually sold to margarine makers or the manufacturers of butter substitutes, and is often used mixed with a preparation of cotton oil. Animal fat being the chief raw material used by such makers, the business of recovering and rendering fat is usually carried on in connection with soapmaking business. Perhaps the most important animal fat is tallow, which is divided into two definite classes, beef tallow and mutton tallow. The quality depends not only upon the part of the animal from which the fat is derived, but also the manner in which the animal has been fed. *See* TALLOW.

LARD is obtained from the fat of the kidneys and intestines of the hog, together with that portion lying beneath the skin. The quality varies according

to the part of the animal the fat is obtained from. Where lard is prepared on a large scale the different parts are rendered separately, thus giving definite qualities. For instance, in the American market, whence comes much of the lard that reaches this market from abroad, the term "Neutral Lard No. 1" is applied to the fat which is obtained from the interior of the pig rendered while perfectly fresh. It is used almost exclusively by margarine manufacfacturers. "Neutral Lard No. 2" is another grade which is chiefly used by confectioners, and there are various other grades. The method of preparing is to carefully melt the raw material, which is first freed as far as possible from flesh, sinews, and skin, and is then cut into small pieces by means of a machine. The melting pan is often steam jacketed, and the fat is stirred by wooden paddles while being extracted until it is quite white. It is strained before being placed in cooling vessels, and again stirred while it is actually cooling, although it is important to suspend the operation before the mass gets solid. The specific gravity of lard at 15° C. is 0·931. Lard oil is obtained from lard by pressure. It is somewhat similar to olive oil in appearance, and is valuable for lubricating purposes. The solid portion of the tallow left behind in the presses is useful for candle manufacture. HORSE FAT is used in leather manufacture for lubricating and for the manufacture of soft soaps. BONE OIL and BONE FAT are important products, and are obtained from the bone marrow and also from the bone itself. In the manufacture of glue, gelatines, and size the process includes the preparation of considerable quantities of bone fat. The extraction of the oil is either done by boiling, steaming, or extraction by a solvent.

The FISH OILS obtained from the livers of various animals are of considerable commercial importance, particularly cod liver oil, which is largely used in currying leathers as well as for medicinal purposes. Shark liver oil is also produced to a considerable extent. Whale oils are obtained from several animals, in addition to the Greenland whale, such, for instance, as the seal, walrus, sperm whale, porpoise. Seal oil is of various grades (*see* SEAL OIL), and among fish oils there are those obtained from the herring, pilchard, sardine, salmon, sprat, and other fishes. As indicating the very wide field from which oils and fats are derived, a few of the animals and vegetables from which they are obtained, in addition to those already mentioned, may be given: apricot, badger, belladonna seed, brazil nut, candle nut, chamois, chicken, cress seed, cucumber seed, dog, domestic duck, gingelly, goose, hare, honesty, horse-chestnut, laurel, Niger seed, nutmeg, palm, reindeer, roebuck, Scotch fir seed, spruce fir seed, sunflower, seakale, thistle, wild goose, wild rabbit.

The most interesting oils at this time are, perhaps, MAIZE OIL and TUNG OIL (*q.v.*), or Chinese wood oil, which bid fair to increase considerably in use.

A. S. J.

Oils, Chemistry of. The term "oil" is not capable of exact definition, as it is applied to substances of widely different classes. Three classes of oils may be distinguished: (1) BURNING AND LUBRICATING OILS: These are usually composed of PARAFFINS (*q.v.*), OLEFINES (*q.v.*), and NAPHTHENES (*q.v.*) These occur naturally in the earth. (2) FIXED OILS: Oils which cannot be distilled (at any rate under ordinary atmospheric pressure) without decomposition. They are usually obtained from animals and from the fruits and seeds of plants, and chemically they are glycerine esters of saturated (butyric and higher) and unsaturated (oleic, etc.) acids of the fatty series. (3) ESSENTIAL OR VOLATILE OILS: As the name implies, they are volatile; that is, they distil unchanged at the ordinary pressure, and most of them distil in steam. They are obtained from plants, some from roots, some from stems, some from leaves, some from fruit, and usually by distilling with steam; but some, like oil of lemon, by pressure. They have distinctive odours, and are used in many ways, as in perfumery, medicine, mixing paints. They belong to widely different classes of chemical compounds, *e.g.* hydrocarbons. *See* TERPENES. *Alcohols and Phenols:* Oil of cloves contains eugenol (*q.v.*); oil of peppermint contains menthol (*q.v.*); oil of lavender contains linalool (*q.v.*) *Aldehydes:* Oil of cinnamon contains cinnamic aldehyde; oil of bitter almonds contains benzaldehyde (*q.v.*) *Ketones:* Examples of these will be found under TERPENES, where they are mentioned incidentally. *Esters:* Oil of wintergreen is methyl salicylate; oil of limes, neroli oil; jasmin oil and others contain linalyl acetate. Oils are colourless or yellow liquids, insoluble in water, except some of the essential oils, which dissolve enough to give an odour to the water. They are rarely pure or even nearly pure substances, but oil of wintergreen is nearly pure methyl salicylate; every other oil mentioned above is a mixture of substances.—W. H. H.

Oil Shales (*Geol.*) Argillaceous rocks of sedimentary origin which contain diffused hydrocarbons in a state which admits of their being distilled into paraffin oil on the proper application of heat. The term is properly restricted to those rocks of this class which contain the hydrocarbons in quantities sufficient to leave a profit after all the working and other expenses have been paid. Oil shales occur in thin beds like coal seams, and are finely laminated. They are generally sooty brown in colour, which becomes paler in the powder, resulting from a scratch or a streak. The rock is about as hard as biscuit, and therefore easily cut with a knife, which leaves a shining mark, having a lustre nearly like that of cut wax. Thin sheets of oil shale are elastic. This elasticity is dependent, like the degree of waxiness of the cut surface, upon the percentage of hydrocarbon present, of which these characters form a rough test. Oil shales graduate vertically and also laterally into ordinary shales, and are commonly interstratified with rocks of this type to an indefinite extent. The Scottish oil shales are confined to geological horizons near the middle of the Lower Carboniferous Rocks, and are practically limited in their geographical distribution, even on these horizons, to parts of Mid and West Lothian. Rocks of similar character occur sparingly in other geological formations in Britain, of which the chief is in the Kimeridge Clay of the south of England. This and various other impure oil shales have occasionally been used in the furnaces of steamboats in lieu of coal. There are reasons for believing that oil shales have been formed in lagoons, in which solutions of sulphate of lime more or less concentrated by evaporation have further decomposed macerated vegetable matters and converted part of the products into gummy compounds which have diffused through the argillaceous sediments at the bottom of the lagoon. The geological evidence lends but little support to the old view that the hydrocarbon was

due to the distillation of coal seams by the heat connected with the intrusion of eruptive rocks.—J. G. G.

Oil Stone (*Carp., Eng., etc.*) A flat stone of fine grain, used for setting or finishing the cutting edge of tools. Many oil stones consist of some kind of slate. The best known forms are the Turkey, Charley Forest, Arkansas, and Washita.

Oil Varnishes (*Dec.*) The group of varnishes made from linseed oil and gums, and used by house and carriage painters, etc., as distinguished from turpentine, water-, and spirit-varnishes. *See* VARNISHES.

Old English (*Typog.*) A comprehensive term applied to most types of the Black letter order, including those used in the fifteenth century and the more modern varieties.

Old Face (*Typog.*) A name given to a robust form of Roman types originally used by the early Flemish printers, and of which the Elzevirs are examples; they were subsequently copied by William Caslon. The letters are somewhat rude, but strong in form and without violent contrasts between the thick and thin lines. The term is generally used to distinguish founts of this character from the lighter and more elegant "Old Style."

Double Pica Old Face.	Typography.
Double Pica Old Style.	Typography.

Old Fustic. *See* DYES AND DYEING.

Old Man (*Mining*). A term applied to former and unknown workers in a mine.

Old Red Sandstone (*Geol.*) A general name for an important group of Deuterozoic formations which were laid down under continental conditions during the Devonian Period. Taking them as a whole, the rocks are characterised by a red coloration; and on some horizons the strata consist of sandstones. At the top is the Upper Old Red Sandstone, which heralds the Carboniferous Period. The Upper Old Red lies with an unconformity representing an hiatus of several miles upon all the rocks older than itself. The highest member of the next below is the Orcadian or Middle Old Red Sandstone, which was preceded in time by the Caledonian Old Red, which, again, lies with a violent unconformity upon the uppermost Silurian rocks, and all the rocks older than that.

Old Sand (*Foundry*). The sand forming the floor of a foundry; it is used for the parts of a mould which do not come into contact with the casting.

Old Style (*Typog.*) The designation of (1) a nineteenth century Roman type of light and elegant face, with a tendency to very fine lines in the upright strokes and serifs. *See* OLD FACE. (2) A style of arrangement in bookwork and display in jobbing composition.

Old Woman's Tooth (*Join.*) A ROUTER or plane for levelling the surface of grooves, etc., which lie below the general level of the surface of woodwork. The plane iron is narrow, and its cutting edge projects below the bottom or sole of the plane by an amount equal to the depth of the groove which is being cut.

Oleaceæ (*Botany*). A dicotyledon natural order found in tropical and temperate climates. It includes economic plants such as the olive and ash.

Olefiant Gas (*Chem.*) *See* ETHYLENE.

Olefines (*Chem.*) An olefine is a hydrocarbon containing n carbon atoms united in an open chain, and $2n$ hydrogen atoms in its molecule; n may be any whole number from 2 upwards. As n carbon atoms united in an open chain can unite with $(2n + 2)$ hydrogen atoms at the most, the olefines are said to be unsaturated. This state of unsaturation is conventionally represented by a double line joining the two carbon atoms having the deficiency in hydrogen, for it is found by experience that the unsaturation consists always in two adjacent carbon atoms, each having one hydrogen atom less in any given olefine than the same two carbon atoms have in the corresponding paraffin hydrocarbon into which it can always be converted. Examples of olefines:

Ethylene .	$CH_2 = CH_2$
Propylene .	$CH_2 = CH - CH_3$
Butylene .	$CH_2 = CH - CH_2 - CH_3$
Pentene .	$CH_2 = CH - CH_2 - CH_2 - CH_3$

It is clear that the compound $CH_3-CH=CH-CH_3$ is isomeric with butylene; it may be called butene-2 (*see* NOMENCLATURE) or symmetrical dimethyl-ethylene; it is sometimes called pseudo-butylene. It is an interesting substance because it exhibits another form of isomerism. *See* STEREOISOMERISM. Position isomerism can occur with the olefines just as it does with the paraffins (*q.v.*) Example:

Butylene . . . . $CH_2=CH-CH_2-CH_3$

Isobutylene (Methyl-2-propene), $CH_2 = C\begin{smallmatrix} CH_3 \\ CH_3 \end{smallmatrix}$

On account of their unsaturated character the olefines show many additive reactions: (1) They unite with hydrogen in presence of finely divided platinum or nickel to form the corresponding paraffins:

$$\begin{array}{c} CH_2 \\ \| \\ CH_2 \end{array} + H_2 = \begin{array}{c} CH_3 \\ | \\ CH_3 \end{array}$$

(2) They unite with halogens directly, *e.g.* ethylene gives ethylene dibromide:

$$CH_2Br$$

(3) They unite with hydriodic, hydrobromic, and sulphuric acids directly on heating; the negative part of the acid molecule attaches itself to the carbon atom containing the least hydrogen, *e.g.*

$$\begin{array}{c} CH_2 \\ \\ CH_2 \end{array} \text{ gives } \begin{array}{c} CH_3 \\ | \\ CH_2I \end{array} \qquad \begin{array}{c} CH_3 \\ | \\ CH \\ \\ CH_2 \end{array} \text{ gives } \begin{array}{c} CH_3 \\ | \\ CH.HSO_4 \\ | \\ CH_3 \end{array}$$

Ethyliodide.

(4) They unite with hypochlorous acid to form chlorhydrins:

$$\begin{array}{c} CH_2 \\ \| \\ CH_2 \end{array} \text{ gives } \begin{array}{c} CH_2Cl \\ | \\ CH_2OH \end{array} \qquad \begin{array}{c} CH_3 \\ | \\ CH \\ \| \\ CH_2 \end{array} \text{ gives } \begin{array}{c} CH_3 \\ | \\ CHCl \\ | \\ CH_2OH \end{array}$$

(5) On gentle oxidation they yield glycols (*q.v.*), but on strong oxidation they break down at the double linking, *e.g.* propylene strongly oxidised gives acetic and formic acids. (6) Most olefines undergo polymerisation. The olefines occur to some extent with the paraffins in crude petroleum; and ethylene forms the principal illuminant in coal gas. They are

obtained in many ways. A few are: (1) Heating a paraffin alcohol with sulphuric acid:

$$\begin{array}{l} CH_3 \\ | \\ CH_2OH \end{array} + H_2SO_4 = \begin{array}{l} CH_3 \\ | \\ CH_2HSO_4 \end{array} + H_2O$$

Ethylhydrogen Sulphate.

$$\begin{array}{l} CH_3 \\ | \\ CH_2HSO_4 \end{array} = \begin{array}{l} CH_2 \\ \| \\ CH_2 \end{array} + H_2SO_4$$

(2) From monohalogen substituted paraffins by heating with alcoholic potash:

$$\begin{array}{l} CH_3 \\ | \\ CH_2I \end{array} + KOH = \begin{array}{l} CH_2 \\ \| \\ CH_2 \end{array} + KI + H_2O$$

Ethyliodide.

(3) Electrolysis of a solution of the potassium salt of succinic acid and its homologues:

$$\begin{array}{l} CH_2COOK \\ | \\ CH_2COOK \end{array} \text{ gives } \begin{array}{l} CH_2 \\ \| \\ CH_2 \end{array}$$

Pot. Succinate.

Oleic Acid (*Chem.*) $\begin{array}{l} C_8H_{17}.C.H \\ \qquad \| \\ H.C.(CH_2)_7COOH. \end{array}$

A colourless liquid; no taste or smell; melts at 14°; boils at 223° under a pressure of 10 mm. of mercury; insoluble in water, but easily in usual organic solvents. Turns yellow, then brown, on exposure to light and air. Hydriodic acid converts it into stearic acid; it is also changed to stearic acid by heating with hydrogen in contact with finely divided nickel spread on pumice stone. Nitrous acid changes it to the stereoisomer elaidic acid (*q.v.*); it adds bromine, and is oxidised by potassium permanganate like the olefines (*q.v.*) It occurs as its glycerine ester, TRIOLEIN, in a large number of oils and fats; *e.g.* olive oil, cod liver oil, lard, goose fat, etc. To obtain the pure acid, olive oil is boiled with caustic potash solution; the liquid is treated with lead acetate, forming the lead salts of the acids; the precipitated lead salts are dried and extracted with ether, which dissolves lead oleate; the lead is precipitated with hydrochloric acid, and the ethereal solution of oleic acid is filtered off and evaporated. The pure acid is obtained by fractional distillation of the residue from the ether in a vacuum. Oleic acid forms many salts, of which the lead salt is the most important, because it is the chief constituent of lead plaster. *See also* IODINE ABSORPTION.

Oleograph. A picture or a reproduction of a picture printed in oil colours: a chromolithograph.

Oleo-Margarine (*Foods*). The term applied in the United States to margarine (*q.v.*)

Oligocene (*Geol.*) A name now much used for the subdivision of the Tertiary Rocks in which a *few* living species of marine mollusca, as compared with the extinct species, are to be found. The formation is of much importance on the Continent, but in Britain is represented only by a small thickness of strata of fluvio-marine origin in the Isle of Wight.

Oligoclase (*Min.*) An aluminium sodium and calcium polysilicate; one of the Felspars corresponding to a mixture of three parts of Albite to one of Anorthite. Triclinic. Usually greyish or yellowish. From Scandinavia and many places in America.

Olive (*Botany*). The fruit of *Olea europæa* (order, *Oleaceæ*) is valued for the oil which it yields and as a comestible when pickled in an unripe state. It is much cultivated in Mediterranean countries, as well as in other suitable regions.

Olive Oil. *See* OILS.

Oliver (*Eng.*) A primitive form of mechanical hammer used by blacksmiths; it is now obsolete.

Olivine (*Min.*) A synonym for CHRYSOLITE (*q.v.*)

Olla (*Pot.*) (1) An earthenware pot used by Spanish peoples for cooking and other purposes. (2) The mess of meat and vegetables cooked in such a utensil. (3) A porous jar for keeping drinking water cool.

Ombrometer (*Meteorol.*) An instrument for recording automatically the time, quantity, etc., of a rainfall. *See also* RAIN GAUGE.

Omnibus Bars (*Elect. Eng.*) Heavy conducting bars in an electric generating station, to which the terminals of the dynamos are attached.

Once Marked Octave (*Music*). The seven notes commencing with middle C (*q.v.*) In organ nomenclature the once marked octave is an octave higher than the above. *See also* PITCH.

One-at-Once Wheel, One-at-Once Engine (*Lace Manufac.*) Hand and power machine respectively for conducting the process of One-at-Once Winding.

One-at-Once Winding (*Lace Manufac.*) A system by which the brass bobbins are wound, one at a time, upon a spindle revolving at a great speed. By this system the end from the fresh source of supply is simply tied to the end of whatever may be upon the bobbin and the bobbin filled up.

One Coil Transformer (*Elect. Eng.*) An AUTO TRANSFORMER. *See* TRANSFORMER.

Onyx (*Min.*) A variety of CHALCEDONY (*q.v.*) showing parallel banding. The bands are of different absorptive power, and advantage is taken of this to make some bands take up a solution of sugar; on treatment with sulphuric acid the sugar is charred, and thus the black and white banding of the jeweller's onyx is produced.

Oolite (*Geol.*) A rock formed of small spheroidal pellets of carbonate of lime, and which bears some resemblance to the "hard roe" of a fish. The structure of each pellet resembles that of an onion, as it is built up of concentric coats. These severally show a fibrous structure radiating from the centre of the pellet. The core of the pellet, in the case of typical oolite, usually consists of a fragment of some other body. Oolitic structure may arise in various ways; but, in the typical oolites, the pellets have been formed by the organic agency of an alga. In some other cases they are due to organico-chemical agency, as in the Carlsbad "Sprudelstein." Large grained oolite is often distinguished from the normal type as Pisolite. Oolitic structure occurs chiefly in the limestones of Jurassic age; but it is by no means uncommon in rocks older or newer in the geological series.

Op. (*Music*). The abbreviation of *opus* (work), a form of numbering musical compositions in order of publication. An opus may consist of one or more numbers.

Opal (*Min.*) Hydrous silica in an amorphous form. The amount of water varies. Many varieties show beautiful internal colours and are used as gems. Such come from Hungary and Australia. The common varieties are usually milky white to yellow and brown, with a resinous lustre. Some are opaque and dark coloured.

Opalite (*Build.*) A glazed substance about ⅛ in. thick, fixed on the surface of walls to represent glazed brickwork.

Opal Plates (*Photo.*) A porcelain or glass plate with an opaque white glaze, coated with a sensitive film similar to those used on bromide printing papers; used for making positive prints.

Opaque (*Paint.*, *etc.*) The term applied to a pigment or substance that is impermeable to light and which is therefore not transparent. *See* BODY.

Open Belt (*Eng.*) A driving belt which is not crossed.

Open Chain Compounds (*Chem.*) When two or more carbon atoms are united in a compound they are said to form a chain. When there are three or more carbon atoms united together, two possibilities present themselves with regard to the carbon atoms at the ends of the chain: (1) They may be united; (2) they may not be united. In the latter case we have an open chain compound. Examples:

$$CH_2 = CH - CH_3 \qquad H_2C \overset{CH_2}{\angle \!\!-\!\!-\!\!\diagdown} CH_2.$$

Open Chain. Closed Chain.

Open Circuit (*Elect.*) An interrupted or broken circuit.

Open Coil Armature (*Elect. Eng.*) An armature whose coils do not form part of a closed or complete circuit during the whole of each revolution.

Open Diapason (*Music*). A stop having no plug in the top of the pipes found on both the pedals and manuals of an organ (*q.v.*)

Open Hearth Processes (*Met.*) Processes for the production of steel from pig iron in reverberatory furnaces, as distinguished from the Cementation or the Bessemer Process. In this system pig iron is mixed with wrought iron, steel scrap, or with iron ores rich in oxides. *See* STEEL, SIEMEN'S PROCESS, METALLURGY, *and* FURNACES.

Opening (*Cotton Manufac.*) The first process in cleaning cotton. The fibres are separated or opened out by getting a thorough shaking, thus freeing the pure cotton from dirt, seed, broken leaf, and other foreign substances. The chief forms of openers are (1) CREIGHTON, (2) PORCUPINE, (3) MODIFIED WILLOW, to which may be attached a hopper feeder if necessary.

—— (*Typog.*) When newspaper copy is given out in small portions it occasionally happens that one of the pieces is in hand longer than the others. If a gap is thereby caused, the compositor who is behindhand is said to be in the "opening."

Open Joint (*Patternmaking*). The wide parts of large patterns are often made of a number of pieces of wood, separated by narrow spaces to allow for expansion of the wood without producing distortion when the moisture of the mould acts on the pattern.

Open Mouth (*Eng.*) A punching or shearing machine in which the jaws are formed like a letter C, allowing the edge of a wide plate to be inserted.

Open Notes (*Music*). The notes given (1) by the open strings of musical stringed instruments; (2) by wind instruments when neither slide nor piston nor hand is used. *See* VIOLIN, HORN, TROMBONE, *under* MUSICAL INSTRUMENTS.

Open Pattern (*Eng.*) A pattern which only produces the main outline or contour of the required casting in the sand, leaving the rest of the mould to be finished by hand. Also termed a SKELETON PATTERN.

Open Pig (*Met.*) Soft cast iron pigs having a loose crystalline structure.

Open Sand (*Foundry*). Castings made in a mould whose top is open to the air are said to be made in "open sand."

Open Scale (*Phys.*, *etc.*) A scale is said to be open when its divisions are fairly wide apart, *e.g.* the term is applied to thermometers with wide spaces between the marks which denote degrees.

Open Score (*Music*). A score having but one part written on each stave. *See also* SCORE.

Open Shed, Open Shedding (*Weaving*). Applied to shedding motions, *e.g.* tappets, dobbies, Jacquards. The system of shedding the heddles or heald shafts by which any particular group of shafts may be retained in the upper or lower position for any required number of picks. It is the opposite in principle to the CLOSED SHED (*q.v.*)

Open Space (*Hygiene*). The Model Byelaws provide that a new house must have along its whole frontage an open space measuring at least 24 ft. to the boundary of any land or premises immediately opposite. In the rear there must be an open space, exclusively belonging to the house, at least 150 superficial feet in area and free from any erection above the ground level, except a closet and an ashpit. It must extend along the entire width of the house, and must measure in no case less than 10 ft. from every part of the back wall of the house. If the house be 15 ft. high, the distance must be 15 ft.; if 25 ft., 20 ft.; and if 35 ft. or more, at least 25 ft.

Open String (*Carp. and Join.*) *See* CUT STRING.

—— (*Music*). In stringed instruments, whether bowed (*e.g.* the violin) or plucked (*e.g.* the guitar), a string is said to be OPEN when it is free to vibrate along its whole length, *i.e.* when it is not "stopped" by pressing the finger down upon it. *See* MUSICAL INSTRUMENTS.

Opera Glass (*Light*). An opera glass or field glass consists of a pair of telescopes, usually of the type invented by Galileo. There is a convex object glass of focal length F, and a concave lens of focal length f, separated by a distance $F - f$. The image is erect, and the magnification is in the ratio $\frac{F}{f}$.

Ophicleide (*Music*). A brass instrument which took the place of the serpent. The ophicleide has now given way to the tuba (*q.v.*) *See* MUSICAL INSTRUMENTS—WIND (BRASS).

Ophitic Structure (*Geol.*) A structure first noticed in the Ophites of the Pyrenees, which were so called on account of their resemblance in colour pattern to that of many snakes. Subsequently the same structure was found in other types of rocks. It consists essentially of a large patch constituting part of a single crystal of one mineral (and proved to be so by the examination of a thin section in polarised light), which encloses several crystals of another mineral in consequence of the period of consolidation of the two being different. Holocrystalline and Ophitic structures are characteristic of true dolerite, in which large plates of one of the Pyroxenes enclose

several crystals (usually lath shaped in form) of a Plagioclase felspar, which is generally Labradorite. Ophitic structure may occur in other rocks besides dolerite.

Opistodomus (*Architect.*) *See* CELL.

Opium (*Botany*). The drug is obtained from *Papaver somniferum* (order, *Papaveraceæ*) by incision of the unripe capsules, from which the latex exudes, and by evaporation becomes hard. Opium contains many alkaloids.

—— (*Chem.*) The dried juice from the unripe capsules of the white poppy (*Papaver somniferum*). It is a reddish brown soft mass, which hardens and deepens in colour when kept. Characteristic smell. It contains a large number of substances—resin, caoutchouc, albumin, and many (eighteen) alkaloids, the latter combined with meconic, acetic, and sulphuric acids for the most part. There are many varieties of opium, *e.g.* Smyrna, Egyptian, Indian, etc. These differ in the amount of alkaloids they contain, and are generally estimated for the morphine (*q.v.*) which they contain. The most important alkaloids contained in opium are Morphine, Narcotine, Codeine, Papaverine (*q.v.*)

Opoponax (*Botany*). A gum resin obtained from the milky juice of the roots of *Opoponax chironium* (order, *Umbelliferæ*). It is now used only in perfumery.

Opossum (*Zool.*) A marsupial mammal found in North and South America. *Didelphis virginiana* is the North American species, and is valued on account of its fur.

Opposition (*Astron.*) The position of a celestial body when its elongation is 180°. The moon at full is said to be in "opposition."

Optical Activity (*Phys.*, *Chem.*) The property possessed by certain substances of rotating the plane of polarisation of plane polarised light which traverses the substance.

Optical Centre of a Lens (*Photo.*) A point such that all rays whose direction *inside* the lens (or that direction produced, if the point lies outside the lens) passes through it emerge parallel to their original direction; the ray appears therefore to be undeviated if it pass through the optical centre of a thin lens. If normals be drawn to the two surfaces of the lens, so as to be parallel to each other, then a line drawn through the points where these normals cut the surfaces will in general intersect the axis at the centre of the lens.

Optical Isomerides (*Chem.*) Compounds which differ only in their behaviour towards a ray of plane polarised light. Examples of such substances are the different forms of lactic acid (*q.v.*), of tartaric acid (*q.v.*), of mandelic acid (*q.v.*), etc.

Optical Lantern. *Also termed* MAGIC LANTERN or simply LANTERN. It consists essentially of a BODY or box containing the source of light, a CONDENSER (*q.v.*), a support to carry the SLIDES, and an OBJECTIVE or, as it is also termed, a FOCUSSING or PROJECTION LENS. *See* LANTERN OBJECTIVE. The light may be obtained from an oil lamp (usually having several wicks), but more commonly the oxyhydrogen light (*q.v.*) or some form of electric light is used. An arc light produced by a continuous current is the best illuminant; the Nernst light is far the most convenient, and is for many purposes equal to the arc.

Optically Active Substances. Substances having the power to rotate the plane of polarisation of a ray of plane polarised light. *See* STEREOISOMERISM, ASYMMETRIC CARBON ATOM, *and* POLARISATION.

Optic Axis (*Light*). 1. The axis of symmetry of an optical system, more often termed the OPTICAL AXIS to distinguish it from the following. 2. A direction in a doubly refracting crystal along which the substance behaves as a singly refracting medium; *i.e.* a ray traversing the crystal in this direction is not split up into two. *See also* DOUBLE REFRACTION.

Opuntia (*Botany*). A genus of *Cactaceæ* native to America. The "prickly pear" (*O. vulgaris*) and "Indian fig" (*O. Ficus Indica*) are well known examples.

Or (*Her.*) The heraldic term for the metal gold. When arms are represented without colour in drawings or engravings, *or* is indicated by small dots. *See* HERALDRY.

Orange (*Botany*). The well known fruit of the evergreen tree *Citrus aurantium*, largely cultivated in subtropical regions. *See* CITRUS.

—— (*Paint.*) A colour produced by a mixture of red and yellow pigments. *See* COLOURS.

Oratory (*Architect.*, *etc.*) A small chapel, or a room in a house, monastery, or church, arranged for private worship.

Orb (*Her.*) *See* MOUND.

Orbit (*Astron.*) The path in which a heavenly body moves, *e.g.* that of the moon round the earth or the earth round the sun. CLOSED ORBITS are circles or ellipses. OPEN ORBITS are parabolas or hyperbolas.

Orchestra (*Architect.*) (1) In the theatres of the ancient Greeks a semicircular space in front of the stage. This space was occupied by the CHORUS (*q.v.*). The corresponding space in Roman theatres was occupied by seats intended for senators and other important persons. (2) In a modern theatre, etc., that part of the building occupied by the band of musicians.

—— (*Music*). (1) A body of instrumental performers. (2) The part of a building in which the instrumentalists and singers are placed.

Orchestration (*Music*). The art of writing for an orchestra; of employing the different kinds of instruments—stringed, wind, and percussion—to obtain contrast and tone colouring. Orchestration and instrumentation are the same.

Orchidaceæ (*Botany*). A well known order of *Monocotyledons* found in temperate and tropical climates. The essence known as Vanilla, obtained from *Vanilla planifolia*, is the only product of commercial value.

Orchil. *See* DYES AND DYEING.

Order (*Biol.*) A group of genera (*see* GENUS) which have certain characteristics in common, *i.e.* which resemble each other more than they do any other genera. Thus the genera *Rosa* (rose), *Pyrus* (apple, pear, etc.), *Fragaria* (strawberry), *Prunus* (plum), *Rubus* (blackberry, raspberry), etc., are grouped together to form the Order *Rosaceæ*.

Orders (*Architect.*) *See* ARCHITECTURE, ORDERS OF.

Ordinario (*Music*). Ordinary: usual.

Ordinary Ray (*Light*). *See* DOUBLE REFRACTION.

Ordnance Datum (*Surveying*). The ordnance or datum line by which all heights are fixed in the Ordnance Survey. It is 12½ ft. below Trinity high water mark, and 4½ ft. above Trinity low water mark.

Ordnance Survey (*Surveying*). The official survey of Great Britain and Ireland undertaken by the Government and carried out by officers selected from the Royal Engineers, who prepare maps and plans.

Ordovician (*Geol.*) A term proposed by Professor Lapworth for the great group of marine sediments and associated volcanic rocks which formerly went by the various names Upper Cambrian, Cambro Silurian, and "Lower Silurian." It is typically developed in Wales and in Cumberland. The use of the term prevents the ambiguity which that of any of the others carried with it.

Ore (*Mining*). A mineral or rock from which a substance of economic value can be extracted with profit. Thus Iron Pyrites (*q.v.*), though containing a considerable quantity of iron, is not an iron ore, since the iron cannot be profitably extracted; but it is an ore of sulphur, and is used extensively as such in the manufacture of sulphuric acid.

Oreillette (*Arm.*) The part of the helmet that protected the ears.

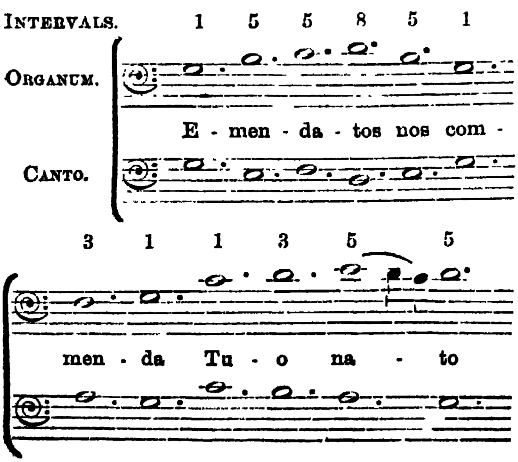
Organ (*Biol.*) A portion of an animal or plant having some definite function.

—— (*Music*). *See* MUSICAL INSTRUMENTS—WIND (KEYED).

Organic Chemistry. The chemistry of the carbon compounds. A few carbon compounds such as carbon monoxide, carbon dioxide, carbon disulphide, the carbonates, and the metallic carbides are usually dealt with in works on Inorganic Chemistry.

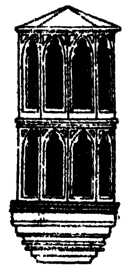
Organ Pipe Coral. *See* CORAL.

Organum (*Music*). An added part to the Canto Fermo (*q.v.*) in old music, which firstly was in unisons and octaves, then in consecutive fourths or fifths, fresh intervals gradually being allowed to be added through succeeding centuries. The following fragment of a hymn taken from Sir Hubert Parry's *Art of Music* will show the style of organum in the thirteenth century:



Organzine (*Silk Manufac.*) Silk thread for warp purposes, doubled and thrown of sufficient strength to stand the strain of weaving.

Oriel Window (*Architect.*) A bay window on an upper floor overhanging the face of the wall below.



ORIEL WINDOW.

Oriental Alabaster (*Min.*) *See* CALCITE.

Oriflamme (*Archæol.*) The banner of the Abbey of St. Denis: a banderole of orange red coloured silk, attached to a gilt lance and terminating in two points. It was the standard of the early kings of France, and was handed to them on setting out for war by the Abbot of St. Denis.

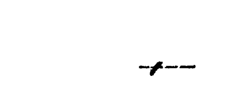
Origanum (*Botany*). A genus of *Labiatæ*. *O. vulgare* is the common herb Marjoram. Oil of Marjoram is distilled from *O. majorana*.

Orles (*Her.*) This is one of the subordinaries, a diminutive of the "bordure," but detached from the outer edge of the shield. Sometimes blazoned by early heralds as an inescutcheon voided. *See* HERALDRY.

Ornaments (*Music*). Embellishments, grace notes. The principal are: (1) THE TURN, which is indicated by a ~ placed above or below a note. When an accidental is placed above or below any ornament it shows that the highest or lowest note respectively is to bear that accidental.

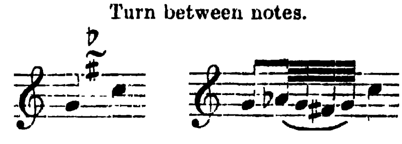
Written. Played.

Turn over a note.



Turn over a dot.

Turn between notes.

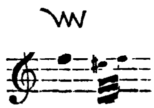


(2) THE INVERTED TURN is indicated by ≀ or

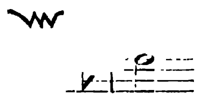
Written. Played.

(3) THE SHAKE, or TRILL, which is indicated by *tr.* or *tr*, and consists of a rapid alternation of the

principal (written) note with the diatonic note above, which may be either a semitone or tone according to the degree of the scale on which the shake appears. Care must be taken to see in what key the shake appears, as the diatonic note above of the temporary key is the one to be used. Bach, Handel, Mozart, Haydn, and other composers of the eighteenth century generally commenced the shake with the note above, except in the case of a shake commenced immediately after a rest, which was termed *trill ex abrupto*, when the shake always commenced on the principal note. Hummel and later composers, excepting Chopin, who reverted to the older style of Bach, commenced with the principal note. Bach generally indicated the shake as follows:



or by a note of anticipation after the W, as—

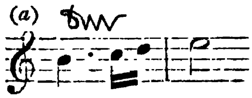


A shake usually, though not invariably, ends with a turn.

THE SHAKE.

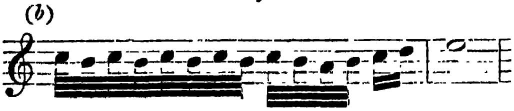
Written.

(a)

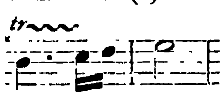


Played.

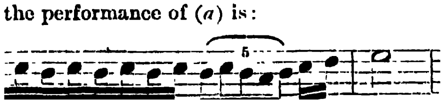
(b)



In modern music this shake (*b*) is written:



whilst the performance of (*a*) is:



(4) **The Mordente**, and (5) **The Inverted Mordente**, also called **Pralltriller** or **Schneller**. These (4 and 5) are shown under **Mordente**, p. 413. (6) **The Slide, Schleifer**, or **Tierce Coulée**.

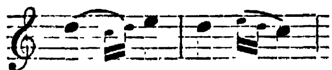
THE SLIDE.

Written. Played.

Written. Played.

It will be seen that the accent always falls on the principal note, and that the time taken by the ornamental notes is robbed from that principal note, whereas in the *Nachschlag* the time of the small notes is taken from the preceding note. The following shows the *Nachschlag* and *Schleifer*:

Written.

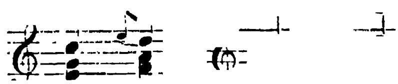


Nachschlag. Schleifer.

Played.

The slur shows which is the schleifer. (7) The Appoggiatura (*q.v.*):

Written. Played.

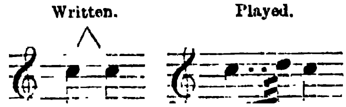


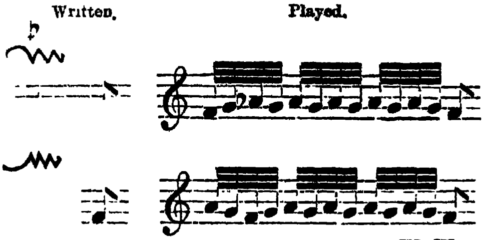
(8) The Acciaccatura (*q.v.*):

Written. Played.

In addition to the above, there were in older music other ornaments, a few of which are shown below:

Written. Played.





W. W.

Orpiment (*Min.*) Sulphide of arsenic, As_2S_3. Arsenic = 61, sulphur = 39 per cent. Orthorhombic, but usually in foliated masses, not in crystals. Of a beautiful lemon yellow colour. Sectile and flexible. The artificial orpiment is used as the pigment King's Yellow. From Bohemia, Hungary, Transylvania, etc.

—— (*Paint.*) A rich yellow pigment compounded from sulphur and arsenious oxide.

Orris Root (*Botany*). The prepared rhizomes of *Iris florentina* (order, *Iridaceæ*) are extensively used in perfumery and in the manufacture of "Essence of Violets."

Orr's Zinc White (*Dec.*) *See* ZINC WHITE.

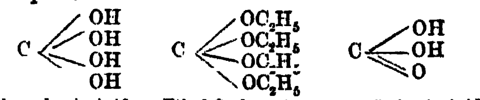
Orthochromatic (*Photo.*) This term is generally understood to mean the correct rendering of the luminosity or brightness of colours in monochrome by photographic means.

Orthochromatic Plate (*Photo.*) A plate which has been specially prepared for photographing coloured objects, and in which the colour sensitiveness has been obtained by the addition of certain dyes to the emulsion. In order, however, to gain full advantage of this addition, it is necessary to employ an orange screen to cut off some of the blue and violet light. The proper selection of this screen is a matter of importance, as should it absorb too much of these rays, those colours would photograph too dark.

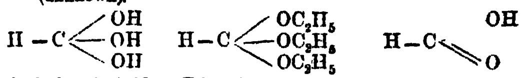
Orthochrom T. (*Photo.*) A sensitising dye stated to give to photographic plates sensitiveness for green, yellow, orange, and red, and to confer a high degree of sensitiveness generally.

Orthoclase (*Min.*) Aluminium and potassium polysilicate, $K_2O . Al_2O_3 . 6SiO_2$. Silica = 64·2, alumina = 18·4, potash = 16·95 per cent. Monosymmetric, in thick prisms; often twinned in one of three ways, the twin planes being respectively parallel to the orthopinacoid, to a clinodome, and to the basal plane, in the Carlsbad, Baveno, and Manebach types of twinning. Colour: white, grey, red, and in the variety Amazonstone, green. Sunstone and moonstone are other varieties which are used by lapidaries. In Cornwall, Aberdeen, Bohemia, Norway, Switzerland, etc.

Ortho-Compounds (*Chem.*) The prefix ortho is used in chemistry in two ways. First, to denote what may be called a normal or ordinary compound, as distinguished from others which are not normal. Examples: Orthophosphoric acid was so called when other phosphoric acids were discovered, and had to be distinguished from it. Orthoboric acid is so called because it is the normal or common boric acid, and has to be distinguished from other boric acids. The prefix is also used in organic chemistry to distinguish derivatives of certain unknown acids which are related to the ordinary carboxylic acids in such wise that the latter are anhydrides of the former. Examples:

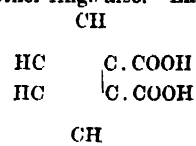


Orthocarbonic Acid (unknown). Ethyl Orthocarbonate. Carbonic Acid.

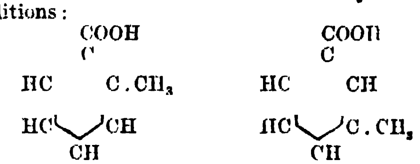


Orthoformic Acid (unknown). Ethyl Orthoformate. Formic Acid.

Second, the prefix is used to denote two adjacent positions in the benzene ring (*see* BENZENE), and occasionally in other rings also. Example:



which is phthalic acid, may be called benzene orthodicarboxylic acid. A ring consisting of four carbon and two nitrogen atoms is known as the diazine ring, and when the nitrogen atoms are adjacent we have the orthodiazine ring. Ortho-compounds have certain characteristic features; *e.g.* ortho-acids form anhydrides. *See* PHTHALIC ACID. Orthodiamines give many condensation reactions which meta- and paradiamines do not give. An ortho-substituent often hinders a reaction in which its fellow ortho-substituent is concerned. Thus, in making the ethyl esters of the toluic acids, while 59 per cent. of meta-acid was made into ester, only 26 per cent. of the ortho-acid was formed under exactly the same conditions:



Orthotoluic Acid. Metatoluic Acid.

Orthodiagonal (*Min.*) The lateral axis of the monosymmetric system which is at right angles to the principal axis.

Orthodome (*Min.*) A form of the monosymmetric system: it is a prism whose axis is the orthodiagonal; the four faces are regarded in opposite pairs of two.

Orthopinacoid (*Min.*) A form of the monosymmetric system whose faces are parallel to both the orthodiagonal and to the vertical axis.

Ortol (*Photo.*) This developer is said to be a mixture of hydroquinone with a sulphate of methyl-ortho-amido-phenol, $C_6H_4OHNHCH_3$. It is readily soluble in water, and produces a colourless solution. Ortol by itself has no developing power, but on the addition of sodium carbonate development takes place rapidly.

Oryza (*Botany*). A genus of grasses, including the rice plant (*O. sativa*).

Os (*Chem.*) The symbol for OSMIUM (*q.v.*)

Osazones (*Chem.*) Dihydrazones in which hydrazine residues are attached to adjacent carbon atoms. Only osazones derived from phenyl hydrazine,

$C_6H_5NHNH_2$, are mentioned in this article; such osazones are usually termed phenylosazones, but they will be called simply osazones for brevity. The simplest osazone is derived from glyoxal or from the simplest possible sugar glycolose, which is the monohydric alcohol of glyoxal:

$$\begin{array}{l} HC:O \\ \quad | \\ HC:O \\ \text{Glyoxal.} \end{array} + \begin{array}{l} H_2N.NHC_6H_5 \\ \\ H_2N.NHC_6H_5 \\ \\ \end{array} = \begin{array}{l} H.C:N.NHC_6H_5 \\ \qquad | \\ H.C:N.NHC_6H_5 \\ \\ \end{array} + 2H_2O$$

$$\begin{array}{l} H.C{<}\begin{smallmatrix} H \\ OH \end{smallmatrix} \\ \quad | \\ H.C:O \\ \text{Glycolose.} \end{array} + 3H_2N.NHC_6H_5 = \begin{array}{l} H.C:N.NHC_6H_5 \\ \qquad | \\ H.C:N.NHC_6H_5 \\ \text{Glycolose Osazone.} \end{array} +$$

$$2H_2O + NH_3 + C_6H_5NH_2$$

Osazones are formed by substances of the general formulæ:

$$\begin{array}{ccc} R & R & R \\ | & | & | \\ (1)\ CO & (2)\ CO & (3)\ CHOH \\ | & | & | \\ CO & CH_2OH & CHO \\ | & & \\ R & & \end{array}$$

where R may be hydrogen or a complex group. All sugars containing aldehyde and ketone groups form osazones, and their osazones serve to distinguish between them, *e.g.* dextrose and lactose, which resemble each other closely in their tests, can easily be distinguished by making their osazones and examining the latter under the microscope. They are all prepared in a similar manner; *e.g.* to make glucosazone, 1 part glucose in 20 parts water is warmed for an hour and a half (for the best yield) on the water bath, with 2 parts phenylhydrazine hydrochloride and 3 parts sodium acetate, when the osazone crystallises out. It may be recrystallised from alcohol. Osazones are yellow crystalline solids, insoluble in water, soluble in alcohol. The osazones of the sugars have only a definite melting point when rapidly heated. They possess reducing properties. The action of hydrochloric acid on glucosazone is very important: it yields phenylhydrazine hydrochloride and glucosone:

$$\begin{array}{l} CH_2OH \\ \quad | \\ (CHOH)_3 \\ \quad | \\ C:N.NHC_6H_5 \\ \quad | \\ H.C:N.NHC_6H_5 \\ \\ \end{array} + 2H_2O = \begin{array}{l} CH_2OH \\ \quad | \\ (CHOH)_3 \\ \quad | \\ CO \\ \quad | \\ HCO \\ \text{Glucosone.} \end{array} + 2H_2N.NHC_6H_5.$$

The glucosone on reduction with zinc dust and dilute acetic acid yields lævulose. Thus glucose (*q.v.*) can be converted into lævulose. Other osazones of the sugars also yield osones in a similar way.

Oscillating Cylinder (*Eng.*) A cylinder swinging on pivots, termed TRUNNIONS, and having its piston rod connected directly to the crank pin, without any connecting rod.

Oscillation. A general term for a "to and fro" movement, however produced.

——, **Centre of.** *See* PENDULUMS.

Oscillations, Electrical (*Elect.*) *See* OSCILLATORY DISCHARGE.

Oscillatory Discharge (*Elect.*) If the plates of a charged condenser be connected by a conductor (whose resistance does not exceed a certain value) a series of very rapid alternations of charge are set up, the plates of the condenser becoming in turn positively and negatively charged. An alternating current of very high frequency thus flows in the conductor; but it rapidly dies away as the original energy of the charged condenser is dissipated in the form of heat. If C be the capacity of the condenser, L the self induction, and R the resistance of the circuit by which the plates are connected, there will be no oscillations if R^2 be greater than $\frac{4L}{C}$. If the resistance be small, the period of the oscillations is approximately $T = 2\pi\sqrt{LC}$.

Oscillograph (*Elect.*) An instrument for showing the changes in a rapidly varying current or E.M.F., *e.g.* for indicating the wave form of an alternating current. It is in principle a galvanometer whose natural period of vibration is very small compared with the period of the alternating current.

Osirid Pier (*Architect.*) A form of pier used in Egyptian architecture, *e.g.* at Luxor, having a colossal figure of Osiris carved on its front face.

Osler's Anemometer (*Meteorol.*) An instrument invented by Osler for determining the pressure of wind. By means of clockwork a record of this pressure is obtained for every instant of time.

Osmiridium (*Chem.*) *See* IRIDIUM.

Osmium and its Compounds (*Chem.*) Os. Atomic weight, 191. A bluish white metal; infusible in anything except the electric arc; sp. gr. 22·5, that is to say, the heaviest metal known; oxidises to the volatile tetroxide when heated in air; insoluble in aqua regia after it has been strongly heated, not otherwise; heated in chlorine, it forms, according to the amount of chlorine, $OsCl_2$, $OsCl_3$, $OsCl_4$. Osmium can be crystallised from its solution in tin. The metal occurs along with platinum, and remains behind as OSMIRIDIUM (*see* IRIDIUM) when the ore is treated with aqua regia. It is obtained by converting the osmium in the alloy into the tetroxide, which is volatile (*see* IRIDIUM); the tetroxide is dissolved in caustic potash, and the solution reduced with alcohol to potassium osmate, K_2OsO_4, which is dissolved in water and precipitated with ammonium chloride. The precipitate heated in hydrogen yields the metal. Several oxides are known ($OsO_2 : Os_2O_3 : OsO_3 : OsO_4$). Only the tetroxide OsO_4 is important; it is often called osmic acid. It is formed by heating the metal in air, when the oxide sublimes in shining needles. It is soluble in water, alcohol, ether. Smells like chlorine, readily volatile, distils in steam. The vapour attacks the eyes and mucous membrane in a dangerous way. Its aqueous solution is reduced by many metals. Sulphur dioxide forms a blue solution. It has feeble acid properties, but does not redden litmus. Used as a stain in microscopy. Forms compounds of unknown nature with the albumins. Osmium forms complex cyanogen and ammonium compounds.

Osmosis (*Phys.*, *Chem.*) If two liquids be separated by a porous partition, there will be in general a tendency for the liquids to traverse the partition—*e.g.* let a solution of copper sulphate in water be separated from pure water by a partition consisting of a sheet of parchment; the water will pass through in one direction, and the dissolved substance in the other. This process is termed OSMOSIS.

Osmotic Pressure (*Phys.*, *Chem.*) Let a solution and a solvent be separated by a semi-permeable partition, which permits the passage of the solvent,

but not of the dissolved substance. The solvent will pass through until it exerts equal pressure on both sides of the partition; the total pressure exerted by the solution will then exceed that exerted by the solvent by an amount equal to that exerted by the dissolved substance alone. This amount is termed the OSMOTIC PRESSURE of the dissolved substance. In the case of a dilute solution (if it is not an electrolyte) the osmotic pressure obeys laws very closely resembling the fundamental laws of gases: (1) it is proportional to the concentration; (2) its variation with temperature is the same for all substances, the pressure probably being proportional to the absolute temperature; (3) solutions containing the same number of dissolved molecules per unit volume exert the same pressure. *See also* SOLUTIONS.

Osones (*Chem.*) *See* OSAZONES.

Ossia (*Music*). Or this instead. An alternative passage of music.

Ossicles, Auditory (*Zool.*) A series of small bones (the *malleus*, *incus*, and *stapes*) in the tympanic chamber of the ear. They serve to convey the vibrations from the tympanic membrane ("drum") to the internal ear.

Ostensoir, Ostensory. A monstrance (*q.v.*) for displaying the Host to the congregation.

Ostinato (*Music*). A ground bass, *i.e.* a bass which repeats over and over again in a composition. A fine example may be found in J. S. Bach's Passacaglia in C minor for the organ.

Ostrich (*Zool.*) A family (*Struthionidæ*) of the subclass *Ratitæ*, or flightless birds. The common African ostrich (*Struthio camelus*) differs slightly in colour from the Somali type (*S. molybdophanes*). The plumage forms a valuable article of trade.

Ottava (*Music*). An octave; *e.g.* ottava bassa or 8va bassa, an octave lower.

Ottoman *or* **Royal Cord** (*Silk Manufac.*) A plain corded silk, woven as Gros, with three or more picks in the same shed, but having an additional binder warp, the threads of which intersect each pick, keeping them apart and giving the cord an extended flat appearance.

Ottoman Rib (*Textile Manufac.*) Also termed SOLEIL. A ribbed fabric in which lines or bars traverse the cloth, but on which the rep is formed entirely in the warp.

Ounce. *See* WEIGHTS AND MEASURES.

Out (*Typog.*) When a compositor has omitted any words, a line or sentence, each omission is called an "out."

Outcrop (*Geol.*) The outer edge of strata where these come either directly to the surface or end off against some newer formation. The form of the outcrop varies on the one hand with the dip or inclination of the strata, and on the other with the shape of the surface which intersects those strata.

Outer Forme (*Typog.*) The forme that contains the first page of a sheet.

Outer String (*Carp. and Join.*) In a staircase the string (*q.v.*) farthest from the wall, *i.e.* the string over which the handrail is fixed.

Outer Tympan (*Typog.*) A frame used on hand presses. It is covered with parchment, and each sheet of paper to be printed is placed upon it. *See* TYMPANS.

Outfall Sewers (*Civil Eng.*) The large main channel conveying sewage (after it leaves the area of collection) to the place where it is to be disposed of.

Outgo (*Plumb., etc.*) The outlet of a trap.

Outlier (*Geol.*) A portion of a stratum which has been isolated from the main mass by the removal of some of the rock around, so that the outlying mass is surrounded on all sides by strata of older date. *Cf.* INLIER.

Outline (*Art, etc.*) (1) The contour of a figure, or the line or lines by which it is bounded in the plane of vision. (2) A drawing which represents an object merely by lines, not a finished view.

Out of Gear (*Eng., etc.*) (1) Gear or spur wheels are out of gear when their teeth do not engage with each other. (2) A general expression for "out of order."

Out of Register (*Print.*) (1) When pages on one side of a sheet do not fall exactly within the area of those printed on the other side, or when line does not fall upon line, or (2) when a work or design is produced in more than one colour and the separate printings do not fall into their proper positions, the work is said to be "out of register."

Output. (1) The energy developed in a given time by any prime mover or source of energy. (2) The amount of work produced by a workman, machine, factory, etc.

Outside Callipers (*Eng., etc.*) Callipers (*q.v.*) with the points curved inward, so as to enable the external diameter of an object to be measured by them.

Outside Crank (*Eng.*) A crank consisting of, or equivalent to, a single lever arm placed at the end of the crank shaft.

Outside Cylinders (*Eng.*) Cylinders of a locomotive placed outside the main frame.

Outside Gouge (*Carp., etc.*) A gouge with the bevel on the outer or convex surface; the ordinary form of carpenter's gouge.

Outside Lap (*Eng.*) *See* SLIDE VALVE.

Outside Lining (*Carp. and Join.*) The linings of a cased frame nearest the reveals.

Outside Reams (*Print.*) Reams of machine or hand made paper containing two quires of imperfect sheets, one quire placed at the top and one at the bottom. The price of "outside" reams is usually 20 per cent. lower than that of "good."

Out to Out (*Build., etc.*) In measurements this term means that the dimensions are taken over all.

Ouvarovite (*Min.*) A calcium chromium garnet of approximate composition, $SiO_2=35$, $Al_2O_3=5$, $Cr_2O_3=22$, $CaO=30$ per cent. Cubic. in dodecahedral crystals of emerald green colour. From the Ural Mountains.

Oval. A closed curve of an egg shape, not to be confused with the ellipse. An oval is symmetrical only about its longer axis.

Oven Coke (*Met.*) Coke specially prepared by heating in closed chambers, and retaining a much larger amount of carbon than ordinary gas coke.

Over All *or* **Sur (le) Tout** (*Her.*) A bearing that surmounts or is placed over others in the field is said to be over all.

Overblowing (*Music*). A term used when too much wind is forced through a pipe, causing it to sound one of the harmonics instead of its fundamental tone.

Overcasting (*Bind.*) *See* OVERSEWING.

Overcoil (*Watches*). The outer coil of a Breguet balance spring. *See* BREGUET SPRING.

Over-Compounded Dynamo (*Elect. Eng.*) A dynamo whose windings are so arranged that the voltage at the terminals increases as the load is increased.

Overcrowding (*Hygiene*). Under the Factories and Workshops Act overcrowding in workrooms is deemed to exist when the cubic space for each adult is less than 250 cubic ft., and during overtime less than 400 cubic ft. The minimum standard laid down by the Local Government Board Model Byelaws is 400 cubic ft. per adult (two children under ten to count as one adult) for rooms in which persons both live and sleep, and 300 cubic ft. for rooms used solely for living. *See also* FLOOR SPACE.

Over-Exposure (*Photo.*) An over exposed image appears very quickly during development; but the contrasts between light and shade are not sufficiently marked. This fault may be lessened by using a developer with a small amount of alkali, or by submitting the finished negative to INTENSIFICATION (*q.v.*)

Overflow (*Plumb.*) An outlet pipe fixed to a cistern near the top to prevent the water overflowing.

Overhand Stoping. *See* MINING.

Overhanging Shaft (*Eng.*) A shaft whose end projects some distance beyond the bearing; a pulley on this end is termed an OVERHANGING PULLEY.

Overhauling (*Eng.*) (1) The reversal of the motion of a crane, crab, or other lifting gear, whereby the load descends by its own weight. (2) A general term for the examination of a machine, etc., with a view to repairs.

Overhead Crane *or* **Traveller** (*Eng.*) A crab or crane running on rails mounted on standards or girders so as to travel along a shop above the level of the machinery, in order to lift heavy pieces of work.

Overhead Gear (*Mining*). The HEAD GEAR or structure over a shaft which supports the hauling tackle.

Overhead Railways (*Civil Eng.*) Railways carried on arches, iron or steel viaducts, etc. Examples are the New York, Berlin, and Liverpool Elevated Railways. The first two run along streets, carried on an iron viaduct supported by iron columns; the latter extends for 6 miles behind the docks.

Overhead Trolley (*Elect. Eng.*) *See* ELECTRIC TRACTION.

Overhead Wires, etc. (*Elect. Eng.*) Any system of conducting wires, either bare or insulated, supported at intervals by poles or arms. The wire is of course insulated from the pole at the point of contact; the common system of telegraph wires is a good example of bare overhead wiring.

Overlap (*Eng., etc.*) The amount by which two plates cross each other at a riveted joint, etc.

—— (*Geol.*) A stratum is said to overlap another in cases where the lower one is locally absent. The use of the term is now usually confined to instances in which the two strata referred to belong to the same geological formation. Overlap implies deposition against a sloping surface.

Overlay (*Print.*) Used in connection with the printing of illustrations. Proofs are pulled on three or more pieces of paper of varying substance, and parts are "peeled" or cut away from each. Then all are lightly pasted together and placed in position over the block to be printed, so that the greater thickness is brought to bear upon the darker portions of the picture, the medium upon the intermediate, and the thinnest upon the background or lighter details.

Overpick (*Weaving*). The system of picking in which the picking arm is over the going part or shuttle boxes. Both light and heavy built looms are mounted with this kind of picking motion.

Overpoled Copper (*Met.*) *See* COPPER.

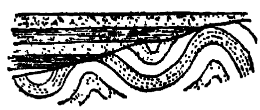
Overrun (*Typog.*) If in a printer's proof any matter is marked to be taken out or inserted, words or lines are transferred from one line or page to another to preserve uniform length. This is termed overrunning.

Oversailing (*Build.*) Overhanging. *See also* CORBELLING.

Oversewing *or* **Overcasting** (*Bind.*) The method of sewing adopted when single leaves, *e.g.* plates, are to be attached to the sections or folded sheets at the end of a book, or when a book consists entirely of single leaves. In the latter case a certain number of leaves, four, six, or eight, are connected together by oversewing, so as to form sections for further treatment, the thread being fastened at the head and tail of each section.

Overshot Wheel (*Eng., etc.*) A water wheel which is driven by water entering the buckets at the top of the wheel.

Overstep (*Geol.*) A stratum is said to overlap another older one in those cases in which the relation between the two is that of an unconformability (*q.v.*) The older strata have, in this case, undergone prior disturbance and denudation, and the newer have been deposited after the movements which caused the disturbance had ceased. Overlap and overstep may coexist in the same section, as is the case in the figure.



OVERSTEP.

Overtone (*Sound, Music*). A sound of higher pitch produced by a vibrating body along with its fundamental tone. Overtones accompany almost every tone which it is possible to produce, and can be detected in very many cases. *See also* HARMONICS.

Overtones (*Music*). Harmonics (*q.v.*)

Ovolo (*Architect.*) A convex moulding. The Roman ovolo is a quarter circle, but the ovolo used by the Greeks is a flatter and more graceful curve. The ovolo is also used, but not extensively, in Decorated Gothic work. *See* CYMA, ECHINUS, *and* COLUMN.

Ovule (*Botany*). The egg shaped body developed within the ovary of a flower, and which after fertilisation becomes the seed.

Ovum (*Zool.*) An Egg Cell, the structure from which an animal is developed after fertilisation or union with a male cell or spermatozoon.

Ox (*Zool.*) *Bos taurus* (family, *Bovidæ*). Apart from the use of the flesh as food, the horns are made into various articles (combs, knife handles, etc.); the cartilages and skin cuttings yield glue; the hide, leather; and that of the calf, vellum.

Oxalates (*Chem.*) *See* OXALIC ACID.

Oxalic Acid (*Chem.*) $\begin{array}{l}COOH\\ |\\ COOH.\end{array}$ White crystalline (monoclinic prisms) solid; crystallises with $2H_2O$; loses its water of crystallisation at 100°; poisonous. On heating, it sublimes in part, and part decomposes to carbon dioxide and formic acid, the latter also partly decomposing to carbon monoxide and water. Heated with glycerine, it gives formic acid (*q.v.*) at 110°, and at a high temperature allyl alcohol. Readily soluble in water and in alcohol; less soluble in ether. Its dilute aqueous solution decomposes on keeping in presence of light. Heated with strong sulphuric acid it gives carbon monoxide and carbon dioxide, the sulphuric acid removing a molecular proportion of water; phosphorus pentachloride reacts in a similar way:

$$\begin{array}{l}COOH\\ |\\ COOH\end{array} + PCl_5 = POCl_3 + 2HCl + CO + CO_2.$$

Oxidising agents, such as acidified potassium permanganate, readily oxidise it to carbon dioxide and water.

$$\begin{array}{l}COOH\\ |\\ COOH\end{array} + O = 2CO_2 + H_2O.$$

Sodium amalgam yields glyoxylic acid with a strong aqueous solution of oxalic acid:

$$\begin{array}{l}COOH\\ |\\ COOH\end{array} + 2H = \begin{array}{l}CHO\\ |\\ COOH\end{array} + H_2O.$$

It is a dibasic acid. Oxalic acid occurs chiefly in the form of its calcium and acid potassium salts; the former is very widely distributed in plants, and is present in urine, and forms also a urinary calculus; the latter also occurs in many plants, *e.g.* sorrel (hence it is called salt of sorrel) and rhubarb. The acid may be obtained synthetically by passing carbon dioxide over finely divided sodium (shaking melted sodium with sand) at 300°:

$$2CO_2 + 2Na = \begin{array}{l}COONa\\ |\\ COONa.\end{array}$$

To obtain the acid from the sodium oxalate, precipitate its solution with calcium chloride and decompose the calcium oxalate with dilute sulphuric acid; decant and crystallise. When an aqueous solution of cyanogen is allowed to stand, ammonium oxalate is formed besides other products, showing that cyanogen may be regarded as the nitrile of oxalic acid:

$$\begin{array}{l}CN\\ |\\ CN\end{array} + 4H_2O = \begin{array}{l}COONH_4\\ |\\ COONH_4.\end{array}$$

The pure acid is best obtained by heating cane sugar with six times its weight of concentrated nitric acid till reaction sets in, allowing it to proceed alone, concentrating, and leaving to crystallise. On the large scale it is obtained by heating the sawdust of a light wood with caustic potash and water, extracting with water, precipitating the solution with milk of lime, and decomposing the calcium oxalate with dilute sulphuric acid. The clear liquid is then crystallised. The following oxalates are important: AMMONIUM OXALATE, $(NH_4)_2C_2O_4$, obtained by neutralising oxalic acid with ammonia; used as a test for calcium. On heating it, some oxamide is formed:

$$\begin{array}{l}COONH_4\\ |\\ COONH_4\end{array} = \begin{array}{l}CONH_2\\ |\\ CONH_2\end{array} + 2H_2O.$$

Heated with phosphorus pentoxide it yields cyanogen. CALCIUM OXALATE, CaC_2O_4, has been mentioned above; it is nearly insoluble in water and in acetic acid; soluble in hydrochloric acid; on heating it gives calcium carbonate and carbon dioxide. FERROUS OXALATE, FeC_2O_4, obtained as a yellow powder on adding a solution of oxalic acid to one of ferrous sulphate; on heating it leaves behind finely divided ferric oxide; its double salt with potassium oxalate, $K_2Fe(C_2O_4)_2H_2O$, is a powerful reducing agent, and is used in photography. *For* ETHYL OXALATE, *see* ETHYL OXALATE, ETHYLAMINES, KETIPIC ETHYL ESTER.

Oxidation (*Chem.*) Oxidation is a name given to any one of three operations, *viz.*

(1) Addition of oxygen to a substance.
(2) Removal of hydrogen from a substance.
(3) The change of an *-ous* salt into an *-ic* salt.

(1) Examples of this process are the combustion of hydrogen in oxygen, the conversion of benzaldehyde on exposure to air or oxygen into benzoic acid, the oxidation of oxalic acid to carbon dioxide and water by an acidified solution of potassium permanganate. Those oxidations which are brought about by free oxygen, and which run spontaneously, are sometimes called autoxidations. The process of addition of oxygen to a substance to form another containing more oxygen is usually not a simple one; there are intermediate reactions. Thus, when hydrogen burns in air or oxygen, a part, at all events, of the water produced arises from the formation and subsequent decomposition of hydrogen peroxide:

$$H_2 = H + H$$
$$H + H + O_2 = \begin{array}{l}H-O\\ \;\;|\\ H-O\end{array} = H_2O + O$$

This is shown by the fact that hydrogen peroxide is always produced in fair quantity when a jet of burning hydrogen is made to play on a piece of ice.

When benzaldehyde is exposed to air, a peroxide is first formed by addition of a molecule of oxygen, and this peroxide oxidises a second molecule of benzaldehyde to benzoic acid, and is itself reduced to the same.

$$C_6H_5C\begin{array}{l}\diagup H\\ \diagdown\!\!\diagdown O\end{array} + O_2 = C_6H_5C\begin{array}{l}\diagup O-O-H\\ \diagdown\!\!\diagdown O\end{array}$$

Benzoylhydroperoxide.

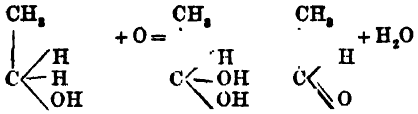
$$C_6H_5C\begin{array}{l}\diagup O-OH\\ \diagdown\!\!\diagdown O\end{array} + C_6H_5C\begin{array}{l}\diagup H\\ \diagdown\!\!\diagdown O\end{array} = 2C_6H_5C\begin{array}{l}\diagup OH\\ \diagdown\!\!\diagdown O\end{array}$$

When a substance is present which the benzoylhydroperoxide can oxidise more readily than it can benzaldehyde, then this substance is oxidised. For example, indigo; then the indigo is oxidised by one of the added oxygen atoms, and the other remains to form benzoic acid.

The two cases, hydrogen and benzaldehyde, are

typical of a very large number of quite similar reactions which are known.

(2) An example of this is the oxidation of alcohol to aldehyde. Here also previous addition of oxygen may be assumed to occur with formation of an unstable compound which breaks down into water and aldehyde:



(3) This kind of change corresponds to the conversion of the salt of a lower oxide into one of a higher oxide, hence it is called an oxidation. The process is, however, electrolytic in character; it consists in adding to the kation a positive charge equal to that carried by a hydrogen ion or a multiple thereof. For example, when oxygen is passed through a solution of ferrous sulphate acidified with sulphuric acid, the hydrogen ions give up their charges to iron ions, and form water with the oxygen:

$$2\overset{++}{Fe} + 2\overset{=}{SO_4} + 2\overset{+}{H} + \overset{=}{SO_4} + O = 2\overset{+++}{Fe} + 3\overset{=}{SO_4} + H_2O.$$

The process of oxidation is effected by reagents or mixtures of reagents, which are called oxidising agents. Examples of oxidising agents are: Oxygen, chlorine in presence of water, nitric acid, hypochlorous and hypobromous acids and their salts, potassium permanganate alone or in presence of sulphuric acid or caustic potash, chromic acid or potassium dichromate acidified with sulphuric acid, ferric chloride, nitrobenzene, and many others. All these reagents act by providing oxygen, except ferric chloride, which gives up chlorine, and the latter removes hydrogen from the compound it oxidises, *e.g.*

$$2FeCl_3 + H_2S = 2FeCl_2 + 2HCl + S.$$

Examples of the action of oxygen are given above. Chlorine oxidises in virtue of its action on water, liberating oxygen:

$$H_2SO_3 + Cl_2 + H_2O = H_2SO_4 + 2HCl.$$

See NITRIC ACID, MANGANESE COMPOUNDS, POTASSIUM COMPOUNDS, HYPOCHLOROUS ACID, LAUTH'S VIOLET, METHYLENE BLUE, ANTHRAQUINONE, QUINOLINE. Chromyl dichloride (*see* CHROMIUM COMPOUNDS) is a valuable oxidising agent in organic chemistry.

Oxide of Zinc (*Dec.*) A valuable white pigment. It is usually manufactured by extracting the metal from zinc ore and burning this metallic zinc in a special furnace. The zinc being heated to a temperature slightly above that of its melting point, it takes fire and burns, giving off dense fumes, which are conducted by means of bags of muslin or other material. These bags are from 30 to 90 ft. long, and in them the fumes at once form what are known as "flowers of zinc." These collect in the bags attached to the main chamber, which are regularly emptied at frequent intervals. Under ordinary conditions six charges may be taken out in one day. The oxide of zinc is then passed through sieves with a very fine mesh, and is ready for use. ZINC WHITE is extensively used in the manufacture of paints, about 85 per cent. of the total quantity produced being used for this purpose. The remainder is used in various industries, including the manufacture of floorcloths, wallpaper, rubber, and for glazing earthenware, etc. The use of late has increased very rapidly owing to the attention of the public having been drawn to the poisonous effects of using white lead. Oxide of zinc possesses the advantage of being much whiter and finer than lead. The whiteness is of importance not only when the work is to be finished in white, but also when the pigment is to form the base of a coloured paint, as freedom from any yellowish cast retains the purity of tint of the added colours. The durability is claimed to be greatly superior to white lead paints, owing principally to the fact that it is uninfluenced by sulphuretted hydrogen and other gases, which are found in the air of all large towns, as well as in the vicinity of stables, lavatories, etc., and which have a disastrous effect upon white lead, changing its chemical nature entirely, and causing it to discolour or turn black. Among painters zinc white is not yet so popular as it should be, probably owing to the fact that it requires to be mixed differently from white lead. When purchased ground in oil in the ordinary way, it should be mixed with refined boiled oil only, and only sufficient turpentine to render it of suitable consistency for application to the work by means of a brush.

Oxides (*Chem.*) Compounds of two elements, one of which is oxygen, are called oxides. The word oxide is also used in organic chemistry to denote compounds formed by the union of alcohol and acid radicals with oxygen. Thus ether is sometimes called diethyloxide, $C_2H_5 - O - C_2H_5$. For convenience the oxides may be divided into several classes, *viz.* BASIC OXIDES, PEROXIDES, and ACID OXIDES; but the division is not a sharp one, for an oxide may belong to more than one class, *e.g.* aluminium oxide is both a basic oxide and an acid oxide. Basic oxides are usually the lower oxides of metals, form salts and water with an acid, and unite directly with acid oxides to form salts, and some unite with water to form alkaline hydroxides (alkalis). Example: $BaO + 2HCl = BaCl_2 + H_2O$: $BaO + SO_3 = BaSO_4$: $BaO + H_2O = Ba(OH)_2$. Basic oxides are made by heating the metal in air or by heating its carbonate, hydroxide, or nitrate, whichever may be most convenient or economical. Peroxides contain more oxygen than basic oxides, and give oxygen on being heated. They give chlorine when heated with hydrochloric acid, oxygen when heated with sulphuric acid. Some peroxides give hydrogen peroxide with dilute acids in the cold, *e.g.* BaO_2 and Na_2O_2. Peroxides can be obtained by heating basic oxides carefully in oxygen, or by heating them with an oxidising agent such as potassium chlorate. Acid oxides are non-metallic oxides, or the highest oxides of metals. They unite with water to form acids and with basic oxides to form salts, *e.g.* $SO_3 + H_2O = H_2SO_4$ and $SO_3 + PbO = PbSO_4$. General methods of formation cannot be given. Sesquioxides are so called because the ratio of the oxygen atoms to the atoms of the other elements is $1\frac{1}{2} : 1$, and not because of any reaction common to them as a class. They have the general formula R_2O_3. Examples: B_2O_3 : Fe_2O_3 : Al_2O_3 : Cr_2O_3. *See also* OXYGEN *and* OXIDATION.

Oxidising Agents (*Chem.*) *See* OXIDATION.

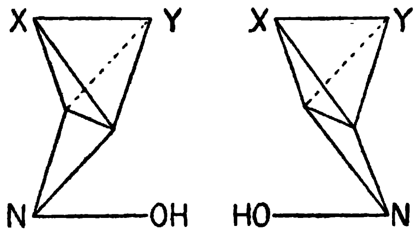
Oximes (*Chem.*) Compounds containing the group $>C = NOH$. There are two classes of oximes, one class derived from aldehydes, and the other from

ketones; the former class is distinguished by the name Aldoximes, and the latter by the name Ketoximes.

$$\underset{\text{Acetaldehyde.}}{\begin{array}{l}CH_3\\ |\\ HC=O\end{array}} + H_2N.OH = \underset{\text{Acetaldoxime.}}{\begin{array}{l}CH_3\\ |\\ HC=NOH\end{array}} + H_2O$$

$$\underset{\text{Acetone.}}{\begin{array}{l}CH_3\\ CH_3\end{array}\!\!>CO} + H_2NOH = \underset{\text{Acetoxime, a Ketoxime.}}{\begin{array}{l}CH_3\\ CH_3\end{array}\!\!>C=NOH} + H_2O$$

Oximes are usually obtained by acting on the aldehyde or ketone with hydroxylamine hydrochloride in presence of caustic soda. When that carbon atom in an oxime which is doubly linked to nitrogen is united to two different groups, one of which may be hydrogen, stereoisomerism may arise. The isomers in the case of a monoxime may be represented thus:



In what follows this will be represented for short as:

$$\text{I.}\quad \begin{array}{c}X-C-Y\\ \ddot{N}-OH\end{array} \qquad \text{II.}\quad \begin{array}{c}X-C-Y\\ HO-\ddot{N}\end{array}$$

For example, acetaldoxime should exist in two forms:

$$\underset{\text{Synacetaldoxime.}}{\begin{array}{c}\\ \ddot{N}-OH\end{array}} \qquad \text{II.}\ \underset{\text{Antiacetaldoxime.}}{\begin{array}{c}CH_3-C-H\\ \|\\ HO-\ddot{N}\end{array}}$$

Form I. is called the Syn form, and Form II. is called the Anti form. Both forms are known in many cases both of Aldoximes and Ketoximes. Acetaldoxime is known as a solid which melts at 47°, and is transformed by heating it to 100° into the other form, which melts at 12°. The latter form is unstable, and passes on keeping into the higher melting variety. Benzaldoxime, when formed by the method given above, exists in the anti form (*see* below); but the syn form can be obtained from it by dissolving in benzene, passing in dry hydrogen chloride, and decomposing the hydrochloride so formed by sodium carbonate. The anti and syn forms of benzaldoxime melt respectively at 49° and 81°. The syn is the stable form for fatty aldoximes, and the anti for aromatic aldoximes. On looking at the formulæ for the syn and anti acetaldoximes given above, it will be seen that the syn form of any aldoxime should more readily lose the elements of water than the anti form. Accordingly, where the two forms are known, that one which loses water more readily is regarded as the syn form. Example: When the two forms of benzaldoxime are cautiously dissolved in acetic anhydride, they form acetates. The acetate of the syn form easily decomposes into benzonitrile and acetic acid on treating with sodium carbonate, the nitrile separating as an oil, while the acetate of the anti form dissolves.

$$\begin{array}{c}C_6H_5-C-H\\ \ddot{N}-OH\end{array} \qquad \begin{array}{c}C_6H_5-C-H\\ \ddot{N}O.OC.CH_3\end{array} \qquad \begin{array}{c}C_6H_5-C\\ \dddot{N}\end{array} + CH_3COOH.$$

$$\begin{array}{c}C_6H_5-C-H\\ \|\\ HON\end{array} \rightarrow \begin{array}{c}\\ \|\\ CH_3.CO.ON\end{array} \rightarrow \text{No decomposition.}$$

As acetates cannot be isolated in the case of the fatty aldoximes, it must be concluded that they usually exist in the syn form, producing an acetate first which is so unstable that it instantly decomposes into nitrile and acetic acid. The ketoximes undergo the Beckmann rearrangement. Example:

$$\underset{\text{Benzophenone Oxime.}}{\begin{array}{c}C_6H_5-C-C_6H_5\\ \ddot{N}-OH\end{array}} \rightarrow \begin{array}{c}C_6H_5-C-OH\\ \|\\ N-C_6H_5\end{array} \qquad \underset{\text{Benzanilide.}}{\begin{array}{c}|\\ NH.C_6H_5\end{array}}$$

This reaction can be used to distinguish between the syn and anti ketoximes. It is brought about by the action of strong acids, acid chlorides (which also yield some acid ester), glacial acetic acid, acetic anhydride, and hydrogen chloride; best of all by dry ether and phosphorus pentachloride. Example of its use in determining configuration is:

$$\underset{\text{Paramethoxybenzophenone (MP 115°).}}{\begin{array}{c}C_6H_5-C-C_6H_4OCH_3\\ \|\\ N-OH\end{array}} \rightarrow \begin{array}{c}C_6H_5-C-OH\\ \|\\ \end{array} \rightarrow \underset{\text{Benzoic Acid Aniside.}}{\begin{array}{l}C_6H_5-CO\\ |\\ NHC_6H_4OCH_3.\end{array}}$$

$$\underset{\text{Paramethoxybenzophenone (MP 137°).}}{\begin{array}{c}C_6H_5-C-C_6H_4OCH_3\\ \|\\ HON\end{array}} \rightarrow \begin{array}{c}HO-C-C_6H_4OCH_3\\ \|\\ C_6H_5.N\end{array} \rightarrow \underset{\text{Anisic Acid Anilide.}}{\begin{array}{l}OC-C_6H_4OCH_3\\ |\\ C_6H_5HN\end{array}}$$

For further information see Werner's "Stereochemie." Oximes are resolved by aqueous acids into their components:

$$(CH_3)_2C:NOH + H_2O = (CH_3)_2CO + H_2NOH.$$

Reduction by hydrogen (sodium amalgam and glacial acetic acid) converts them into amines:

$$(CH_3)_2C:NOH + 4H = (CH_3)_2CHNH_2 + H_2O.$$

The following is an important application of an oxime in the chemistry of the sugars: Glucose yields an oxime by direct reaction with a pure solution of hydroxylamine. On treating this oxime with acetic anhydride and sodium acetate, the penta acetate of the nitrile of d-gluconic acid is obtained. This nitrile loses its cyanogen group on treatment with ammoniacal silver oxide. The product on hydrolysis with hydrochloric acid gives d-arabinose—a pentose:

$$\underset{\text{d-Glucose Oxime.}}{CH_2OH(CHOH)_4CH:NOH} \rightarrow$$

$$CH_2OOCCH_3(CHOOCCH_3)_4CN \rightarrow$$

$$\underset{\text{d-Arabinose.}}{CH_2OH(CHOH)_3CHO.}$$

The formation of oximes is important in characterising aldehydes and ketones.

Oxindole (*Chem.*) $C_6H_4<\genfrac{}{}{0pt}{}{^{1}CH_2}{^{2}NH}>CO$. Tautomeric form, $C_6H_4<\genfrac{}{}{0pt}{}{CH}{N}\!=\!COH$. The lactam of orthoaminophenylacetic acid. Crystallises in needles; melts at 120°; soluble in water; oxidises in moist air to dioxindole, $C_6H_4<\genfrac{}{}{0pt}{}{CHOH}{NH}>CO$; reduces ammoniacal silver; heated with baryta water at 150°, it gives the barium salt of orthoaminophenylacetic acid: nitrous acid gives an isatine oxime, $C_6H_4<\genfrac{}{}{0pt}{}{C:NOH}{NH}>CO$; it easily forms a potassium salt, which with ethyl-iodide and subsequent hydrolysis yields ethylorthoaminophenylacetic acid, showing that in the potassium salt the metal is united to nitrogen. Oxindole is obtained by reduction of orthonitrophenylacetic acid by tin and hydrochloric acid.

Oxonium Compounds (*Chem.*) In certain of its compounds oxygen appears to have marked basic properties; in such compounds the oxygen is divalent, but it can unite with acids and form salts in which the oxygen behaves as a tetravalent element. These salts of tetravalent oxygen are called oxonium compounds, from analogy with ammonium compounds:

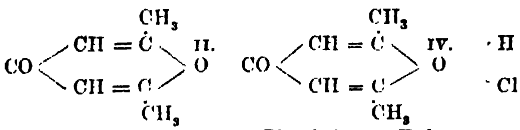
$$\genfrac{}{}{0pt}{}{R}{R_1}>\overset{\text{II.}}{O} \qquad \genfrac{}{}{0pt}{}{R}{R_1}>\overset{\text{IV.}}{O}<\genfrac{}{}{0pt}{}{H}{X}$$

Oxonium Compound.

$$\begin{array}{l}R\\R_2\end{array}>\overset{\text{III.}}{N} \quad > \quad \begin{array}{l}R\\R_1-\\R_2\end{array}\overset{\text{V.}}{N}<\genfrac{}{}{0pt}{}{H}{X}$$

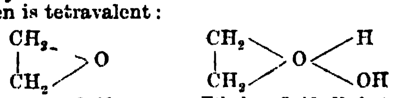
Ammonium Compound.

Examples: Dimethyl pyrone forms salts with many acids, and behaves like a base comparable in strength to a weak base like urea:



Dimethyl Pyrone. Dimethylpyrone Hydro[chloride]

The discovery of the quadrivalence of oxygen in salts of dimethyl pyrone (Collie and Tickle) has led to the recognition of the quadrivalence of oxygen in a large number of organic compounds. Thus an aqueous solution of ethylene oxide precipitates many metals as hydroxides from solutions of their salts, and this is best explained by assuming a compound of ethylene oxide and water to be formed in which oxygen is tetravalent:



Ethylene Oxide. Ethylene Oxide Hydrate.

Ether, acetone, and many alcohols have the property of uniting with acids to form compounds in which the oxygen of the substances mentioned is tetravalent. It is remarkable that complex acids, such as hydroferrocyanic, hydroferricyanic, phosphotungstic, and others seem especially prone to form oxonium salts. The oxonium salts of certain colourless or feebly coloured substances are strongly coloured compounds, and to this phenomenon the name halochromie has been given. Examples are: (1) Dibenzalacetone:

$$\genfrac{}{}{0pt}{}{C_6H_5CH=CH}{C_6H_5CH=CH}>CO$$

a pale yellow solid whose hydrochloride is intensely yellow and hydriodide nearly black. (2) Triphenylcarbinol:

$$\begin{array}{l}C_6H_5\\C_6H_5-\\C_6H_5\end{array}>C.OH$$

a colourless crystalline solid which dissolves in concentrated sulphuric acid with an intense yellow colour.

Oxybaphon (*Archæol.*) A large bell shaped vessel like the Crater, used by the Greeks and Romans for holding wine.

Oxychlorides (*Chem.*) *See* CHLORIDES.

Oxy-Compounds (*Chem.*) These are better called hydroxy-compounds. *See* HYDROXY.

Oxy-Ether Light A substitute for the oxyhydrogen light where coal gas and hydrogen are not available. A stream of oxygen is blown through a tank of ether, and the mixture burnt along with an additional supply of oxygen at the jet. *See* OXY-HYDROGEN FLAME.

Oxy-Gaslight. Coal gas may be used with oxygen under pressure instead of hydrogen. The blow-through jet is used in this case. *See* OXYHYDROGEN FLAME.

Oxygen (*Chem.*), O. Atomic weight, 16. A faintly blue, odourless gas; it is magnetic; boils at − 182°, the liquid is distinctly blue; 1 litre at 0° and 760 mm. weighs 1·43 grs.; 100 cc. water at 0° dissolve 4·9 cc. oxygen at 0° and 760 mm. Oxygen occurs free in the air to the extent of very nearly 21 per cent. by volume or 23 per cent. by weight, when determined after the air has been freed from water vapour and carbon dioxide. As oxygen is dissolved by water it also occurs free in all natural waters. This free oxygen is necessary for the respiration of all plants and animals. Oxygen occurs combined in water (⅞ by weight) and in silica, carbon dioxide, all tissues of plants and animals. It has been calculated that the weight of the atmospheric oxygen on every square centimetre of the earth's surface is about 234 grams, while the same amount of oxygen is contained in a layer of water 260 cm. deep and 1 square centimetre area, while the oxygen in the earth's solid crust is about 10,000 times that in the air. Oxygen may be obtained by heating many oxides, *e.g.* those of mercury, silver, and gold, and all peroxides of metals; also by heating salts of oxy-acids rich in oxygen, such as chlorates, permanganates, perchlorates; by heating peroxides, permanganates, dichromates with sulphuric acid; by the electrolysis of acidulated water, or water made alkaline with caustic potash or baryta water, when the oxygen is evolved at the positive pole; by warming a paste of bleaching powder and water with a cobalt salt. On the large scale it is obtained from the air by Brin's Process (*q.v.*) Oxygen unites directly with most of the other elements: with some, such as phosphorus, sodium, potassium, calcium, at the ordinary temperature; with others on heating, such as carbon, zinc, copper, iron, lead; it does not unite directly with the halogens and the noble metals (silver, gold, platinum). The rate of union depends

on the state of division of the element. Oxidation proceeds so quickly with finely divided iron and lead that they catch fire in air at the ordinary temperature when sufficiently finely divided. All ordinary combustions are due to the union of the oxygen of the air with the thing burned or with the constituent elements of the thing burned, as when coal gas burns; here the free hydrogen unites directly with the oxygen of the air, while the elements of the marsh gas which is contained in coal gas each unite separately:

$$CH_4 + 2O_2 = CO_2 + 2H_2O.$$

As air contains only one-fifth of its volume of oxygen, all substances which burn in air burn much more rapidly, and therefore at a much higher temperature and much more brightly in oxygen. When an element can unite with oxygen in more than one proportion the compound formed by the union of the two will depend on the relative amount of the element and oxygen; thus copper and phosphorus each form lower oxides with a restricted supply of oxygen than they do with a free supply of oxygen. In the case of compounds also the products are usually different when combustion occurs in a restricted supply of oxygen from what they are in a free supply. Sulphuretted hydrogen in a restricted supply of oxygen gives water and sulphur; in a free supply, water and sulphur dioxide. Marsh gas can be made to yield methyl alcohol, formaldehyde and formic acid in a limited supply of oxygen; but in a free supply it yields carbon dioxide and water only. Finally, many, if not all, combustions in oxygen do not occur in the absence of every trace of moisture; carbon monoxide, nitric oxide, phosphorus are examples of substances which will not unite with oxygen in absence of moisture. Oxygen is distinguished from all other gases except nitrous oxide by rekindling a glowing spill, and from all other gases by giving reddish brown fumes with nitric oxide and by turning an alkaline solution of pyrogallic acid brown or an ammonia solution of cuprous oxide blue. Oxygen has the property of uniting with certain compounds of unsaturated character to form unstable substances which possess active oxidising properties. The oxygen united in this way is called "active oxygen," and the process of union is called the "activising" of oxygen. Thus turpentine is a substance which renders oxygen "active." The compounds are supposed to be formed by the addition of a molecule of oxygen, and they have been called "moloxides." The oxygen in these moloxides can oxidise a portion of the unactivised compound, or it can oxidise other substances capable of oxidation when brought in contact with the moloxide. Thus active turpentine oxidises water to hydrogen peroxide; potassium iodide with liberation of iodine, many metals, and indigo solution. One of the best established cases besides turpentine is triethylphosphine:

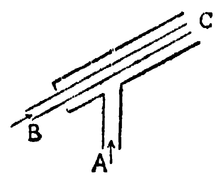
$$(C_2H_5)_3P + O_2 = (C_2H_5)_3P\left\langle\begin{matrix}O\\ |\\ O\end{matrix}\right.$$

The triethylphosphine moloxide can yield triethylphosphine oxide by autoxidation, or it can oxidise another substance such as indigo:

$$(C_2H_5)_3P + (C_2H_5)_3P\left\langle\begin{matrix}O\\ |\\ O\end{matrix}\right. = 2(C_2H_5)_3PO.$$

See OXIDATION.

Oxyhydrogen Flame and Light. Hydrogen burns in air with a non-luminous but hot flame; if the flame be supplied with oxygen instead of with air, a still hotter flame results; the temperature of the flame is sufficient to melt many very refractory substances, *e.g.* quartz and platinum; while certain infusible bodies, such as lime, are raised to a state of brilliant incandescence. Ordinary coal gas gives a flame which is nearly equal to that obtained from pure hydrogen, and may frequently be used instead. For burning coal gas, or hydrogen supplied at low pressures, a BLOW THROUGH JET is generally used: a typical form is shown in the figure. The hydrogen or coal gas enters at A, and burns at the open end of the jet C; here it is fed by a steady stream of oxygen flowing through the central tube B. The form of the mouth C is modified in various ways, but the essential principle remains the same.



When the two gases are obtainable under approximately equal pressures, as, for example, when both are supplied in steel cylinders, a MIXING JET is used. In this case the hydrogen and oxygen are allowed to mix in proper proportions in a small chamber, from which a single tube leads to the jet. If the gases are allowed to mix in exactly their combining proportions (two volumes of hydrogen to one volume of oxygen), there is great risk of explosion, though in a good mixing jet this may lead to no worse result than the "snap" which causes a sudden extinction of the flame. But by using a considerable excess of hydrogen, the arrangement is safe and the flame steady and far more powerful than when the gases are in their combining proportions. The OXYHYDROGEN LIGHT or LIMELIGHT is obtained by allowing the flame to impinge on the surface of a small cylinder of lime (calcium oxide, CaO). This cylinder is usually about 2 in. high and 1 in. in diameter; a hole is bored along its axis through which passes a rod which supports the lime. By means of this rod the lime can be raised and lowered, or turned round, so that a fresh surface can be exposed to the action of the flame.

Oxy-Spirit Light. When coal gas or hydrogen is not available, its place may be supplied by the vapour of METHYLATED SPIRIT (*q.v.*), burnt at a jet resembling that used in the oxyhydrogen light and supplied with oxygen under pressure. *Cf.* OXYHYDROGEN FLAME.

Ozokerite (*Chem.*) A soft yellowish solid which occurs in the ground chiefly in Galicia and Roumania. Its constitution is unknown, but it is probably a hydrocarbon or mixture of hydrocarbons of the olefine series. When bleached it is used under the name of cerasin or ceresine (*q.v.*) as a substitute for beeswax.

—— (*Min.*) One of the hydrocarbons. It is a solid, of a dark brownish colour, resembling wax, and melting at 130° to 140° F. When refined, it yields CERESINE (*q.v.*) From Uphall in Linlithgowshire, Newcastle, Galicia, Moldavia, etc.

Ozone (*Chem.*), O_3. A faint blue gas which has not been obtained free from oxygen; has characteristic smell. The liquid gas is deep blue and very magnetic; it boils at −119° to −125°. The liquid is explosive. It is absorbed by many essential oils, such as turpentine; slightly soluble in water. The gas is easily decomposed by heat into oxygen. On account of the ease with which it gives up one atom

of oxygen and passes into ordinary oxygen it has strong oxidising properties, *e.g.* it oxidises many metals. In the case of mercury a mere trace of ozone is enough to destroy the surface tension of a large quantity of the metal; also many lower oxides are changed by it to higher oxides, many sulphides to sulphates. It oxidises and destroys organic matter so that ozone cannot occur in air which contains much organic matter. It reacts with potassium iodide as follows:

$$2KI + H_2O + O_3 = 2KOH + O_2 + I_2.$$

Here, since a molecule of ozone gives rise to a molecule of oxygen, there is no change of volume. This reaction also serves as a test for ozone when it is known that no other substance such as chlorine is present which can liberate iodine from potassium iodide. Ozone probably occurs in very pure air; it does certainly after the occurrence of electric discharges. It is formed in a large number of processes, *e.g.* in the electrolysis of acidified water, in the silent electric discharge by the kathode rays, and by radium rays; also when moist phosphorus is exposed to air, when sulphuric acid acts on peroxides, permanganates, etc. To obtain it in quantity the silent discharge is passed across a thin layer of oxygen at a low temperature. That ozone has the formula O_3 is shown by weighing a vessel full of oxygen, then weighing the same vessel full of ozonised oxygen, and finding the volume of the ozone in the latter case by absorbing it with turpentine. The difference in weight is the difference between the weight of equal known volumes of oxygen and ozone; and as the density of oxygen is known, that of ozone becomes known. Experiment gave density = 47·8. Ozone is used in the purification of drinking water. Experiments have shown that by combined filtration and ozonisation the number of microbes can be reduced from 100,000 to 600,000 per cubic centimetre of water down to at most 2 to 9 per cubic centimetre. It is also used as a disinfectant in other ways: in bleaching, in oxidising oils, etc. A solution in olive oil is sold under the name "Electron."

Ozonometer (*Meteorol.*) An apparatus which by the use of ozone test papers determines the amount of ozone in the atmosphere.

Ozotype (*Photo.*) The name given to a modified form of carbon printing by the inventor Mr. T. Manly. In this process the print is made upon sized paper sensitised with a mixture of a bichromate salt, manganous sulphate, etc., and when sufficiently printed the unaltered salts are removed by washing in cold water. This initial image forms the basis upon which the finished print is afterwards formed in pigmented gelatine. In this process no reversal of the image occurs.

P (*Chem.*) The symbol for PHOSPHORUS (*q.v.*)

π. The symbol used for the ratio of the circumference to the diameter of a circle; the number 3·1416.

Pacinotti Ring (*Elect.*) An early form of dynamo armature, ring shaped, and provided with projecting teeth.

Packing (*Eng.*) (1) Material placed in a cavity or STUFFING BOX (*q.v.*), through which a piston rod passes, in order to make a steam-tight joint. (2) Material of any kind, *e.g.* wooden blocks, used to raise an object by a small amount.

Packing (*Mining*). A Cornish term for the final dressing of copper or tin ore.

Packing Case. A large box, usually of unplaned timber, with the joints nailed together instead of being dovetailed; often lined with lead, zinc, etc.

Packing Ring (*Eng.*) A PISTON RING (*q.v.*)

Pad (*Build.*) A piece of lead or felt placed under the ends of a steel girder at its bearings.

—— (*Engrav.*) An implement shaped at the base like a broad pestle, and consisting of some soft material covered with silk. It is used for spreading the warm varnish over plates that are to be etched. *See also* ENGRAVING AND ETCHING.

Padding. Superfluous matter in a literary article, speech, periodical, etc., introduced for the purpose of filling up space. Superfluous accessories which detract from the merit of an artistic composition.

Paddle (*Eng., etc.*) (1) One of the blades fixed on the paddle wheel (*q.v.*) of a steamship; more correctly termed a FLOAT. (2) A tool used for spreading various kinds of material in metallurgy, paint mixing (*q.v.*), glass manufacture, brickmaking, etc. (3) A sluice in a lock-gate, or in a weir, for regulating the quantity of water passing through.

Paddle Boat (*Eng.*) A steamboat propelled by Paddle Wheels (*q.v.*); now almost superseded by the use of the Screw Propeller (*q.v.*)

Paddle Box (*Eng.*) The casing over the upper part of a Paddle Wheel (*q.v.*)

Paddle Wheels (*Eng.*) A pair of wheels of large diameter. On the circumference are fixed flat FLOATS, projecting in a radial direction. Paddle wheels were used on all the early types of steamship, but they are now nearly obsolete. The floats were either fixed or else hinged at their base, and actuated by levers in such a way that they entered the water at right angles to the surface; the latter type are termed FEATHERING FLOATS.

Paddling (*Leather Manufac.*) A process of tanning light skins in a pit in which a paddle revolves. The paddle keeps the skins and tan liquor gently moving, and so accelerates the process.

Pad Saw (*Joinery*). A narrow saw that will slip inside the handle (pad) when not in use.

Page Cord (*Typog.*) Small, strong twine with which the pages of type are tied round to secure them temporarily until they are imposed.

Page Gauge (*Typog.*) A narrow piece of wood technically known as reglet, and rather longer than a page of the work to be printed. It is notched at a point where the full page of type, including head and signature line, ends. The purpose is to secure uniform length of pages and to facilitate imposition.

Pagoda (*Architect.*) (1) A Hindoo temple. (2) The lofty, many storied Chinese and Japanese towers are known as Pagodas and also as Taas.

Paint (*Dec.*) A liquid or semi-liquid consisting of one or more pigments reduced to a fine powder and mixed with linseed oil and turpentine or other vehicle (*see* THINNERS), and intended to be used for the preservation or beautifying of the surface to which it is applied. A second class of paints are known as "water paints" (*q.v.*), and require only the addition of water to render them ready for

use. Most paints are made from a base such as white lead, oxide of zinc, lithopone, barytes, or some other white pigment (*see* PIGMENT) mixed with colouring matter in order to produce the required hue. Sometimes a base of an earth colour such as ochre or sienna is used in place of the white. *See* PAINT MIXING. The term "pure paint" is a misnomer, since any mixture of pigments and drying oils would form a paint; in fact, if ordinary road mud were dried, ground in oil, and then thinned with oil and turpentine, it might be said to be a pure paint. When the word "paint" is used in connection with the name of a pigment of well defined composition, it causes vagueness and uncertainty. For example, "white lead" on a package means that the contents consists wholly of white lead or basic carbonate of lead; but if the term "white lead paint" is employed, it indicates a paint, in the composition of which only a certain amount of white lead has been used.

Painters' Brushes (*Dec.*) The brushes with which the painter, the decorator, and the artist apply paint in the execution of their work vary largely in shape, size, and make, scores of different kinds being used according to the exact requirements of the work in hand. They all consist essentially of some sort of flexible bristles, hairs, or fibres, held together by means of twine, wire, or metal bands, and fixed to a suitable handle. The best painters' brushes, which are intended to be used in oil paint, are made of hog's bristles of various kinds, intermixed so as to give "spring" or elasticity, solidity, and strength. These bristles are very expensive, and in the cheaper brushes it is common to find horse hair and other adulterants mixed with them. The result is that the brush is flabby, lacks spring, and does not last long. Genuine bristles can be recognised when viewed under a magnifying glass by their having split ends, while the root will be found to be "flagged," *i.e.* larger than the stem. Horsehair and fibre have both ends alike and of the same size. GROUND BRUSHES are used to apply paint to fairly large surfaces, and are made in different shapes, the chief being the ordinary "round" and "oval" forms. The latter is generally thought to be handier to use than the round form. Ground brushes are made in eight sizes, varying in the weight of bristles from 1 oz. to 8 oz., and usually numbered 1/o to 8/o. The smallest and largest sizes are not much used. The smaller brushes are called SASH TOOLS, and are used in cases where the ground brush is too bulky; for example, on mouldings, sashes, beads, etc. For executing narrow lines and in painting the smallest details, FITCHES are employed. These consist of smaller bristles, formed to make a flat, pointed tool, and held in place by a metal ferrule on the end of a somewhat long handle. "LINERS" are used for drawing lines in paint upon work. They are made with square and bevelled edges, and the bristles are quite stiff. VARNISH BRUSHES are specially made for applying varnish, although some makes are suitable for both paint and varnish. They are flat in form, and the bristles usually taper to form a bevelled edge. This is effected by standing the bristles in a little box with a convex bottom, formed of the same shape as that which it is desired the ends shall assume. DISTEMPER BRUSHES are made in various forms, the most common being termed "one knot," "two knot," and "three knot." The term "knot" means that a bunch of the hair is tied up with wire. The handles are usually made of beechwood. Another form which is rapidly growing in favour is made by binding the bristles in flat form to the stock or handle, either by brass, tin, or leather. DUSTING BRUSHES, as the name implies, are used for removing dust, etc., from a surface before the paint is applied. They consist of long, elastic bristles, somewhat loosely bound, and are made in two forms—round (used in London and the south of England); and flat (used almost exclusively in the north). The latter possesses the advantage that it may be used for removing dust from places where the round brush would not go, *e.g.* between the balusters on a staircase. STIPPLERS are large, flat, square brushes having a handle on the back, and are used for stippling paint work, *i.e. dabbing* a newly painted surface so as to remove brush marks and leave a slightly uneven surface. *See* STIPPLING. STENCIL brushes are usually stiff bristled tools, held together in a tin ferrule or twine binding, and are used both in oil and water paint. *See* STENCILLING. Various additional brushes are used by grainers and sign writers. *See* SIGN WRITING. Ordinary painters' brushes, such as ground brushes and sash tools, when new are too long in the bristles for convenient use, and are therefore "bridled," *i.e.* bound up about halfway with cord. Bridles are sold ready for use, but practical painters usually prefer to make them on the brush. In some makes of brush a small piece of copper wire is bound in with the bristles at each side, so as to be bent back, and form holds for the twine used in forming the bridle. In others two little metal eyelet holes are provided for the same purpose. In all cases the bridle is removed when the bristles have become sufficiently worn to render its further use unnecessary. The care of brushes is of great importance, and yet is frequently neglected. Paint brushes after use should be thoroughly cleansed with turpentine or soap and water, all paint being removed, and should then be wrapped up in paper, with a little camphor or naphthalene to keep away moth, and put away until required in a fairly cool dry place. If, however, the brush is required for use the next day, it is not necessary to take this trouble. It should then be suspended in a can or other suitable utensil full of raw linseed oil, or water may be used instead. The brush should not stand on the bristles, or the weight will cause them to turn to one side, and the brush will remain permanently out of shape. A hole bored through the handle of the brush, and a wire or thin rod passed through it, forms a simple but effective device for the purpose. Varnish brushes are usually suspended in linseed oil, but never water. A better plan is to suspend them in varnish, and in cases where the work is of a delicate character in the same grade of varnish as that in which the brush is used. In this case it is necessary to use a special can having an airtight cover. Whitewash, distemper, and all other brushes used in water need only cleansing, but they must never be put away damp or be stored in a very warm and dry place, or the bristles are likely to become loose. In every case it is best to soak a brush of this kind in water for a couple of hours before using it. Writing pencils should be cleaned in turpentine, and, if they are not to be used for some time, dipped in olive oil or tallow and smoothed out to a point. Brushes that have become hard with paint should be soaked in a liquid paint remover, such as Ball's, or in raw linseed oil, and may then be cleaned with hot turpentine. No brush should be kept in turpentine for a length of time, as it causes the bristles to lose their elasticity. Water has the same effect.—A. S. J.

Painters' Holiday (*Dec.*) A term used to indicate portions of painted work which have been inadvertently skipped or missed. To prevent this it is usual to vary the colour of undercoats somewhat, so that the portions of the surface reached by the paint brush can be distinctly seen.

Painting (Methods). In the history of the technical processes used by the painter the first place must be given, on the ground of antiquity, to what is known as PAINTING IN TEMPERA. This method was followed in remote ages by the decorators of Egypt, Assyria, and of other Eastern countries, as well as by the Greeks and early Italians, and is still counted among the accepted modes of pictorial practice. It is in its mechanism akin to both oil and water colour painting, but it has certain peculiar qualities by which it is distinguished. The colours employed are certain earths and other dry pigments which are made to adhere to the canvas or wall surface by being mixed with a gummy medium such as glue, size, white or yolk of egg, starch, milk, cheese, the juice of the fig tree, or a compound made up of several of these combined. The process is susceptible of many applications and does not limit the artist who uses it to a particular manner of expression. Its results are permanent under proper conditions, and the works for which it has been employed are not seriously liable to chemical change or mechanical disintegration. FRESCO in its various forms has also a history of many centuries. It was much practised in Italy, both in Roman times and during the period of the Renaissance, and its best traditions are still kept up by modern artists in that country. True fresco is a method of painting upon wet plaster with colours mixed with water. These soak into the actual substance of the plaster and become permanently incorporated with it as it dries. Only those pigments which do not suffer from contact with lime can be used, and only so much of the plaster surface as will remain wet while the artist is painting on it can be dealt with in each day's working. An ancient variation of true fresco was used by the Romans. It was called ENCAUSTIC PAINTING, and its peculiar qualities came from the use of wax for a binding medium. Wax was applied to the plaster as a ground, it was often mixed with the pigments themselves, and was finally spread over the face of the finished painting, and then by the application of heat was fused into a solid mass in which the colours were securely locked up and protected from all possibility of damage by atmospheric influences. A modern method, known as SPIRIT FRESCO, also depends upon the use of wax to bind the work together. In this the wax is dissolved in a volatile oil, and the resulting compound is employed as a medium for preparing the wall surface and for mixing with the pigments, so that a fusing effect akin to that in encaustic painting is produced without the use of heat. In another modern variation, WATER GLASS PAINTING, the pigments, mixed with water, are laid upon plaster which has been previously soaked with solutions of ferro-silicic acid and water glass of potassium, and they are set with a fixative which is sprayed or brushed over them after they have dried. All kinds of fresco depend greatly for their permanence upon protection from moisture, and they are easily destroyed by damp soaking into the wall on which they are painted. OIL PAINTING began to be extensively practised towards the end of the fifteenth century. According to tradition it was invented by Van Eyck, a Flemish artist, but its principles were understood at an earlier date, and he seems merely to have systematised them conveniently. It differs from tempera painting chiefly in the substitution of oil or varnish in the place of the albumen or size chosen as the binding medium in the older process. The pigments are mixed with oil and varnish until they become of the right working consistency, and are laid upon canvas, wood panels, or any other equally convenient surface. Under reasonable conditions oil paintings will last for centuries, but they are liable to changes in tone from the darkening of the oil vehicle and to colour alterations from the use of fugitive pigments. The technicalities of the process are, however, so adaptable and so easily controlled that its popularity is quite intelligible. Modern WATER COLOUR PAINTING in its best form is a process of staining white paper with washes of transparent colour. The pigments are soluble in water, but they are prepared with the admixture of a small amount of gummy medium which makes them flow more easily over, and adhere more closely to, the surface of the paper. Work done in transparent water colour is brilliant in effect and full of variety, both of colour and tone, and as the white paper shines through the washes it has a pleasantly luminous quality. Some artists prefer to make their water colours opaque by mixing Chinese white with the transparent colours, and by so doing revert more or less to the practice of the tempera painters ; but the best results are obtained by what is commonly considered to be the more legitimate method of transparent painting. One other technical device must be noted—PASTEL PAINTING. This is really a method of drawing in colours, for the pigments are compressed into sticks with so little binding medium that they work like soft chalk and are made to adhere to paper or canvas merely by the pressure of the hand in drawing. The results attained by such a process are necessarily somewhat fragile, but yet pastel paintings, if they are protected from friction or rough usage, are quite permanent. They do not undergo any chemical changes and are not liable to fade or become discoloured. This method of painting was first used in France in the seventeenth century, and its suitability for pictures of a delicate and fanciful type has made it widely popular with artists. It is still very generally practised.—A. L. B.

Painting, Schools of. The nature of the works achieved by the ancient schools of painting cannot be very exactly estimated. That the Egyptians and the Assyrians were skilful decorators and studied closely some of the best principles of pictorial art can be judged from existing remains, but these remains give a more or less imperfect idea of the full scope of their practice. Tradition assigns to the Greeks also considerable proficiency in painting, but none of their pictures have survived; and of Roman art there have been preserved only examples of mural decoration. Some of these have certainly a freshness of design and a beauty of finish which suggest that the technicalities of painting were well understood by the artists of the period. The knowledge of drawing and the appreciation of colour combination displayed in them imply the existence of high standards of accomplishment and the observavance of well established artistic traditions, so that there was not improbably a fair number of able painters among the Romans. But the real history of painting with which we are concerned began in

the thirteenth century, when Cimabue laid the foundations of the great ITALIAN SCHOOL. This school can be divided into several groups, in each of which there were men who may be placed among the great masters of the world. There were the Tuscans and Florentines, with Giotto (1276–1336), Masaccio (1402–1428), Leonardo da Vinci (1452–1519), and Michael Angelo (1475–1563) as leaders in a company which included also Botticelli, Andrea del Sarto, Luca Signorelli, Filippo Lippi, Sodoma, and Bronzino; there was the Umbrian group, with Perugino (1446–1524) and Raphael (1483–1520), and others like Pinturicchio and Giulio Romano; the Paduan group, with Mantegna (1431–1506), Squarcione, and Schiavone; the Veronese group, headed by Paolo Veronese (1530–1588); and the Lombardy group, with such masters as Domenichino, Guido, Parmigiano, Correggio, and the Carraccis. There was, too, the splendid Venetian school, which began its great career in the fifteenth century with John Bellini (1426–1516), and produced in the years that succeeded Titian (1477–1576), Giorgione (1478–1511), Tintoret (1512–1594), and others like Sebastian del Piombo, Bordone, and Moroni. Altogether the glorious period of Italian art covered nearly four hundred years. Meanwhile there was growing up in the Low Countries another school which was destined to become not less famous. It was made up of two groups, the FLEMINGS and the DUTCHMEN. In the first were included Hubert Van Eyck and Jan Van Eyck, both born towards the end of the fourteenth century; Hans Memling, who flourished in the fifteenth century; Quentin Matsys and Mabuse, who carried on the traditions of the school into the sixteenth century; Rubens, who was born late in the sixtenth century and died in 1640; and Van Dyck (1599–1641). The Dutch masters belong almost entirely to the seventeenth century; among them were Hals (1584–1666), Rembrandt (1607–1669), Terburg (1607–1669), Teniers (1610–1694), and others like Cuyp, Paul Potter, Ostade, Hobbema, and Bol. In the latter part of the fifteenth century and the early part of the sixteenth there were some GERMAN ARTISTS of note—Martin Schongauer, Lucas Cranach, Aldegrever, and Hans Holbein, who died in England in 1543 or 1554. The SPANISH SCHOOL owes its reputation chiefly to the fact that it produced one great master, Velasquez (1599–1660). His contemporaries—Zurbaran, Ribera, and Murillo—were also artists of distinguished capacity, but none of them can be said to have quite rivalled him in power. About a century after Velasquez appeared Goya (1746–1828), who is entitled to a place among the more notable Spanish painters. The FRENCH SCHOOL has a long and honourable record. Its best period began with Nicholas Poussin (1594–1665) and Claude (1600–1682); and in the early eigteenth century it included many men of admirable skill, among them Watteau (1684–1721), Lancret (1690–1743), Chardin (1699–1779), Boucher (1704–1770), Greuze (1725–1805), and Fragonard (1732–1806). A little later came others like David, Delaroche, Gericault, and the Vernets, who helped on appreciably the development of the school in its modern form. The ENGLISH SCHOOL had its real beginning with William Hogarth (1697–1764). There had been artists of native birth before him, but none of them can be said to deserve places in any list of masters. The immediate successors of Hogarth were, however, men of unquestionable importance. Sir Joshua Reynolds (1723–1792), Thomas Gainsborough (1727–1788), George Romney (1734–1802), John Hoppner (1768–1816), Sir Henry Raeburn (1756–1823), and Sir Thomas Lawrence (1769–1830) are all counted now as superlatively accomplished painters of portraits and figure subjects, and J. M. W. Turner (1775–1851) and John Constable (1776–1837) as landscape painters of supreme ability. The English water colour school, too, which came into existence about the middle of the eighteenth century, quickly made a reputation by the power of the men who attached themselves to it and the excellence of the work they produced. The modern schools which have at the present time the fullest vitality are the French, the English, and the Dutch. France is still a centre where the science of painting is admirably understood, and where fine craftsmen abound. In England the older traditions, though modified to some extent by foreign influences, are being soundly carried on; and in Holland a new form of artistic sentiment, derived chiefly from France, has been very successfully grafted on to the sturdy and masculine art of the older Dutch masters. In Italy and Spain there are some skilful executants but hardly any artists of the first rank; and the same may fairly be said of Germany.—A. L. B.

Paint Mixing (*Dec.*) The method of mixing paints and colours employed by painters is a somewhat crude one. A little oil is first placed in a can or paint pot to prevent sticking, and then the base or principal pigment, *e.g.* white lead, zinc white, ochre, etc., ground in oil, is placed in the can, and linseed oil and turpentine are added slowly, together with the necessary quantity of driers (*q.v.*) The pigment is beaten against the side of the can with a piece of wood shaped like an oar or paddle. When the paint is reduced to the consistency of thick cream the colour is added if the paint is to be tinted. This colour is mixed separately with a palette knife on a slab or piece of plate glass, and is added in small quantities to the white in the can. The final operation, and a very necessary one, is to strain the paint through wire gauze so as to remove all small unmixed particles. In the best work, paint is twice strained. The custom of using small mechanical paint mixers, worked by hand, is growing among painters. Liquid or ready mixed paints are manufactured in considerable quantities, and are usually sent out in lever-top tins ready for use. These are mixed mechanically in specially constructed paint mixers, having revolving arms or paddles. In the best forms these arms revolve vertically, so as to stir up the heavier part of the paint, which is apt to settle to the bottom. The art of mixing the very large number of different colours required in modern house painting necessitates considerable experience. The following is a short list of some of the commonest colours and their constituents:—BUFF: French ochre and white lead with a little Venetian red. BRONZE GREEN: Chrome green, yellow, and a little black, or chrome yellow and black alone. BROWN (LIGHT): White, mixed with orange chrome and raw umber. BROWN (DARK): Indian red, lampblack, and yellow ochre. BRICK COLOUR: French ochre, Venetian red, and ochre. CARNATION: Carmine lake added to white. FLESH COLOUR: A little yellow ochre and Venetian red added to white. PURPLE: Indian red, ultramarine, and white. SALMON: White lead, vermilion, and a little yellow ochre. TERRACOTTA: White lead and burnt sienna. LAVENDER: Ultramarine and carmine added to white. SKY BLUE: Prussian blue or cobalt added in small quantities to white. CREAM: French ochre

added to white with a little Venetian red. STONE COLOUR: French ochre added to white with a little burnt umber. IVY GREEN: French ochre, lampblack, and Prussian blue. OLIVE: Lemon chrome yellow with a small proportion of ultramarine and Indian red. PEA GREEN: Chrome green added to white. CHESTNUT: Chrome yellow and Venetian red. CHOCOLATE: Burnt sienna and a little crimson *or* Indian red, lampblack, and yellow ochre. FRENCH GREY: Add drop black to white and a very little crimson and blue. CLARET: Red, umber, and a little black.—A. S. J.

Paint Oils (*Dec.*) That group of drying oils which are sufficiently abundant and cheap to permit of their extensive use in house painting. Linseed oil is the principal oil of this class; but walnut oil (*q.v.*), poppy-seed oil (*q.v.*), and Tung oil (Chinese wood oil) (*q.v.*) are also employed to a limited extent. Rosin oil (*q.v.*) is sometimes used in cheap paints, but it is objectionable from the fact that it does not become permanently hard. (*See also* OILS.)

Paint Stripping (*Dec.*) A term used to indicate the removal of a coat of paint from the surface to which it has been applied. This is always necessary when the old paint is very cracked or blistered, and rubbing smooth with pumicestone or sandpaper would be impossible. The most common method of stripping paint is to employ a painter's torch or naphtha lamp, which is held in the left hand so that the flame is directed over about a square foot of the old paint at the time, the heat causing the paint to quickly soften. This is then removed by means of a specially constructed knife having a square and sharpened end, and held in the right hand. A portable charcoal stove fitted with a long wooden handle is sometimes employed for the same purpose, or a jet of gas taken from an ordinary gas burner by means of a rubber tube may be employed instead. All these methods have the objection that when used indoors they cause a good deal of smoke and smell. Various solvents are, therefore, sometimes employed instead. They consist of two classes, the first being a paste consisting principally of an alkali which softens the paint after having been applied about a quarter of an hour, so that it may then be washed off; the second class consists of various liquids, of which acetone is one of the principal constituents: this is cleaner than the paste, but can hardly be used with advantage outdoors when a high wind is blowing, as the liquid evaporates before the paint is properly softened.

Pair *or* **Pare** (*Mining*). A Cornish term for a gang of miners (more than two in number).

Palæontology (*Geol.*) The branch of science which is concerned with the study of the Past Life of the Earth. Its pursuit requires an extensive knowledge of biology as well as geology, and its followers are now becoming, in consequence, more and more specialists in its various branches.

Palæozoic (*Geol.*) A term much in use even yet for the strata which contain the oldest types of organic remains yet known, from the base of the Cambrian Rocks upward to the top of the Carboniferous Rocks. By some it is still considered to include also the so-called "Permian" Rocks, which, however, in reality forms the natural base of the Mesozoic Rocks. The Palæozoic Rocks are now usually sub-divided into an Upper or Deuterozoic Series, and a Lower or Protozoic (*q.v.*)

Palaestra (*Archæol.*) A public building used by the Greeks as a gymnasium. The chief athletic exercise taught was wrestling.

Pale (*Her.*) One of the honourable ordinaries: a band placed vertically in the middle of the shield, reaching from top to bottom, and occupying about one-third of the field. *See under* HERALDRY.

Palette (*Arm.*) A small plate of metal of various shapes attached to plate armour to protect the armpit

—— (*Eng.*) The breastplate or part of a hand-drill to which the pressure is applied.

—— (*Paint.*) An implement used by painters for the purpose of setting and mixing colours when painting. It generally consists of a flat thin piece of wood (walnut or pear) or porcelain, oval or rectangular in shape, with a hole at one end suitable for the thumb of the left hand to pass through when in use.

Palette Knife (*Paint, etc.*) A thin, flexible blade of metal or other material fixed in a handle. Used for mixing colours on a palette or for laying the paint on certain parts of the canvas; also for spreading printing ink over a surface.

Palimpsest (*Archæol.*) An ancient parchment or other writing material from which the original writing has been effaced to make place for a subsequent writing. The term is sometimes applied to a monumental brass (*q.v.*) which has been turned and engraved on the reverse side.

Paling (*Carp. and Join.*) A fence formed of thin boards overlapping each other longitudinally, and nailed to the rails.

Palisading (*Carp. and Join.*) A fence with battens a few inches apart nailed to the rails.

Pall (*Her.*) A charge in the form of the letter Y. Derived from a vestment peculiar to archbishops, which consisted of a circular band of lambswool worn round the neck, with two pendants of the same width, one before and one behind. Only the front portion is shown in the charge, and this bears crosses *paté fitchée*.

Palla (*Archæol., etc.*) A loose garment or robe worn by Roman women over their other garments. A plain or ornamented cloth used to cover the chalice.

Palladian. A style of architecture named after its introducer, Andrea Palladio (born 1518, died 1580). "It is a sort of medium between that vigorous severity which some exclusive minds abuse in the endeavour to imitate the classic style, and the licentious anarchy of those who refuse to recognise rules, which rules allow of exceptions" (Gwilt's *Encyclopædia of Architecture*, 1891, p. 1331). Palladio's principal works are: S. Giorgio Maggiore, Venice, Basilica, Vicenza (his masterpiece). In England, Inigo Jones (1572—1652) introduced the Palladian style. The banqueting-hall in Whitechapel is an example of his work.

Palladium (*Chem.*) Pd. Atomic weight, 106·5. A shining white metal; melts about 1500°; sp. gr. 11·4; malleable, ductile. The metal easily absorbs hydrogen (*see* OCCLUSION), and this occurs best on warming. Use is made of this property in gas analysis when hydrogen has to be estimated other-

wise than by explosion with oxygen. The metal is partly oxidised in air at a high temperature; it dissolves in nitric acid, forming the nitrate Pd $(NO_3)_2$. Palladium forms a series of salts in which it is divalent; the most characteristic of these salts are: (1) The cyanide, which is formed as a pale yellow precipitate, when mercuric cyanide is added to a solution of a palladium salt; the cyanide gives the metal on heating, and dissolves in potassium cyanide to form a double salt. (2) The iodide PdI_2, which is formed as a black precipitate on adding a solution of potassium iodide to one of a palladium salt; it is insoluble in hydrochloric acid. This metal also forms double chlorides with potassium and ammonium chlorides, *e.g.* K_2PdCl_4 and K_2PdCl_6, the former being the more stable. Palladium occurs free, sometimes nearly pure, but usually with platinum, osmium, etc. It can be separated from the aqua regia solution by nearly neutralising it and precipitating as cyanide. Finely divided palladium can be obtained by boiling a solution of one of its salts with alcohol and caustic soda.

Palladium (*Min.*) This rare element occurs in two forms. The mineral known as PALLADIUM consists of an alloy of the element palladium with platinum and iridium, and is cubic in its crystalline system. The mineral ALLOPALLADIUM is rhombohedral, and consists of pure palladium. Both are found in association with iridium and platinum in Brazil and in the Urals.

Pallas (*Astron.*) The second of the minor planets discovered. Found by Olbers in 1802.

Pallet (*Bind.*) A narrow tool of brass fixed in a handle, and having a straight or a slightly convex working surface. Used for finishing the backs of bound or half-bound books with plain or ornamental lines, either in gilt or antique style.

—— (*Her.*) A diminutive of the pale and one half its width. *See under* HERALDRY.

Pallets (*Clocks and Watches*). The "pads" by which the escape wheel teeth transmit energy to the pendulum or balance.

Pallium (*Archæol., etc.*) The Latin name for the outer garment or cloak worn by the Greeks, especially by the philosophers. *See* HIMATION. A woollen vestment or scarf worn by archbishops in the Roman Catholic Church. *See* PALL (*Her.*)

Palmæ (*Botany*). A highly important order of Monocotyledons found in tropical and sub-tropical regions. The most common form consists of a single stem with the leaves arranged in a crown at the top. *Cocos nucifera* is the Cocoanut Palm. *Sagus Rumphii* (found in the Moluccas) contains starchy material in the stem, from which Sago is obtained. Many other genera are economically important, while some are cultivated on account of their ornamental appearance.

Palm Capital (*Architect.*) A form of capital used in Egyptian architecture. It resembles a series of spreading palm leaves. *See* CAMPANIFORM CAPITAL, CLUSTERED LOTUS BUD CAPITAL, *and* HATHOR HEADED CAPITAL.

Palmer Tyre (*Cycles, Motors*). *See* TYRES.

Palmitic Acid (*Chem.*) $CH_3(CH_2)_{14}COOH$. White crystalline solid; melts at 62°; boils at 278·5° under 100 mm. pressure; insoluble in water; soluble in alcohol and ether. Occurs free in palm oil; but usually it is combined with alcohols forming esters. Thus its cetyl ester is chief constituent of spermaceti. *See* CETYL ALCOHOL. Its myricyl ester, $C_{15}H_{31}COOC_{30}H_{61}$, forms about 80 per cent. of beeswax; its glyceryl ester is the chief constituent of palm oil, and occurs in olive oil, butter, cocoanut oil, soft animal fat. Adipocire, a waxlike substance found when the bodies of animals decay in the earth, is principally potassium and calcium palmitates. Palmitic acid can be prepared from palm oil by hydrolysing with caustic potash, decomposing the solution of potassium oleate and palmitate with sulphuric acid, and crystallising from alcohol till pure. Oleic acid is much more soluble in alcohol than palmitic acid.

Palm Oil. An oil, fat, or butter obtained from the fruit of several species of the palm, chiefly *Elæis guienensis*. When fresh it is of a bright orange colour, and possesses a pleasant odour like violets or orrisroot; but on exposure it soon becomes rancid, and has then a very unpleasant smell. It is used in this country principally for soap and candle making. The sp. gr. at 15° C. is 0·945, and the melting point 27° to 45° C., according to the quality and condition of the oil.

Palm Wax (*Botany*). A species of palm, *Ceroxylon andicolum* (order, *Palmæ*), from South America; yields a waxy secretion used in candle making.

Palstave (*Arms*). A celt of bronze or other metal without a socket, but made so that it could be attached to a handle and used as a weapon.

Paludament (*Archæol.*) A cloak worn over their armour by the highest Roman military officers. A herald's coat.

Paly (*Her.*) A shield is called "paly" when divided by an equal number of vertical lines, the spaces being alternately of metal and colour. *See* HERALDRY.

Paly Bendy (*Her.*) When the last shield is divided by an equal number of lines drawn bendwise.

Pamphlet (*Print.*) A small book containing from one to five sheets stitched together, and generally put into a paper wrapper. A short essay or treatise published alone.

Panama Straw. The fan shaped leaves of a tropical South American plant, *Carludovica palmata* (order, *Cyclanthaceæ*), when very young, are cut into strips and bleached. This material is used for making so-called Panama hats, which are manufactured chiefly in Ecuador and Peru.

Panathenæa. The great annual festival of Athens which celebrated the union of Attica under Theseus. The festival every fifth year was more elaborate than those during intervening years. The celebration included a grand procession to the shrine of Athena (*see* ELGIN MARBLES), musical competitions, and athletic competitions.

Pan Closet (*Hygiene*). The pan or container closet consists of a china basin shaped like an inverted cone, with its outlet guarded by a movable metal pan, which retains water in the basin. This metal pan not only rapidly fouls and wears out, but each time the basin is emptied allows foul air to escape. It is the most objectionable form of closet, and is now prohibited by the model byelaws of the Local Government Board.

Pandemic (*Hygiene*). The term applied to a disease prevalent over a large portion of the globe.

Pane. (1) One of the sheets or pieces of glass forming the divisions of a window, etc. (2) One of the sides of the table or upper portion of a brilliant or cut diamond. (3) The dressed surface of a stone. (4) In irrigation, a space of ground bounded by a feeder and an outlet.

—— (*Eng.*, *etc.*) The narrow end of a hammer head. *Also spelled* PENE, PEEN, PIN, *etc. See* HAMMERS.

Panel. (1) A portion of a surface surrounded by a frame or border and often consisting of some thinner material, *e.g.* the panel of a door. (2) A thin board employed instead of cardboard or canvas in water-colour and oil painting. (3) A large photograph of much greater height than width.

—— (*Bind.*) One of the spaces between the bands on the back of a bound volume. A division or compartment on the cover of a book enclosed by lines or contained within a border.

—— (*Carp. and Join.*) A thin board occupying the spaces between the styles, rails, and muntings of framed joinery.

—— (*Eng.*) The spaces between the upright pieces of a built up girder or similar structure.

Panel Board (*Elect. Eng.*) A SWITCH BOARD (*q.v.*) built up in panels instead of being in one piece.

Panel Gauge (*Join.*) A long marking gauge; the rod or stem may be from 1 ft. to 2 ft. long. It derives its name from the fact that it is used in gauging the width of panels and similar pieces of work.

Panel Machine (*Join.*) A wood planing machine used for planing up small pieces of flat board, such as panels.

Panel Picture (*Paint.*) A picture painted on a panel of wood. The earlier artists frequently painted on panels.

Panel Saw. A joiner's saw for cutting wood across the fibres. It resembles a hand saw, but is smaller, and has about seven to nine teeth to the inch. *See* SAW.

Panes (*Cost.*) Slashes in outer garments, *e.g.* doublets, to show the coloured lining, or to allow of an under garment being seen. This style was much in evidence during the fifteenth, sixteenth, and seventeenth centuries.

Pan Head (*Eng.*, *etc.*) A flat headed rivet.

Panicum (*Botany*). A genus of grasses belonging to tropical and warm temperate regions. Indian millet (*P. miliaceum*) is a valuable cereal.

Pannier (*Architect.*) A CORBEL (*q.v.*)

Panning. The operation of washing auriferous sand, etc., by placing it in a pan to which a slight motion is communicated by the hand. This causes the particles of gold to accumulate at the bottom, the sand, etc., being allowed to pass over the edge with the water.

Panorama. A picture of a landscape or other scene in which all objects that are visible from a fixed point are represented on the inner side of a cylindrical surface, the point of view being the axis of the cylinder; or the picture is unrolled before the spectator, showing the various parts in succession. Invented by R. Barker, of Edinburgh, about 1788.

Pantagraph. *See* PANTOGRAPH.

Pantheon (*Architect.*) A circular building with a domical roof, built by Hadrian in Rome (A.D. 117–138) The portico of sixteen Corinthian columns was taken from an older building erected on the same site by Agrippa in the reign of Augustus. The following are some of the principal dimensions of the Pantheon: Internal diameter, 142 ft. 6 in.; external diameter, 188 ft.; height from floor to outside of "eye," 148 ft. 4 in.; thickness of dome at eye, about 6 ft. The building is lighted solely by means of a circular opening or "eye" in the centre of the dome. This eye is 27 ft. in diameter, and each square foot of it lights nearly 3,400 cubic ft. of the interior.

Pan Tile (*Build.*) A double curved roofing tile.

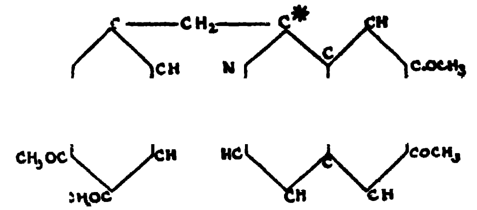
Pantograph. An instrument used for making copies of drawings of a different size from the original. The pencil which draws the copy is connected with a tracing point by a set of jointed link work, so that the movement of the pencil always bears a constant ratio to the movement of the tracing point.

—— (*Lace Manufac.*) An enlarged form of the ordinary pantograph mechanically adapted for producing designs upon fabric in the Swiss embroidery machine.

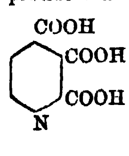
Papain (*Botany*). *See* PAPAW.

Papaver (*Botany*). The poppy is a member of the *Papaveraceæ*. *P. somniferum* yields the drug OPIUM.

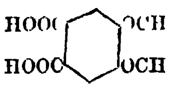
Papaverine (*Chem.*)



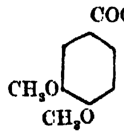
A white crystalline (prisms) alkaloid; melts at 147°; insoluble in water; soluble in chloroform; sparingly soluble in cold, easily soluble in hot, alcohol; in benzene and amyl alcohol soluble to the extent of one part in 37 and 76 parts respectively; optically inactive. It is a tertiary base, as it unites with ethyl iodide; hydriodic acid removes four methyl groups. On reduction with tin and hydrochloric acid, it adds four hydrogen atoms to the ring marked 1, and the carbon atom marked with an asterisk becomes asymmetric; the new base—tetrahydropapaverine—can be resolved into the dextro- and lævo-forms by δ-bromcamphorsulphonic acid. On cautious oxidation with potassium permanganate and sulphuric acid, the CH_2 group of papaverine becomes a CO group, and the papaveraldin so formed behaves like a ketone; also it dissolves in concentrated sulphuric acid, giving a deep coloured solution (Oxonium compound). On stronger oxidation of papaverine, the products are:



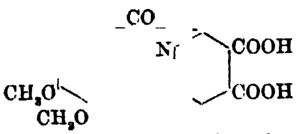
α β γ pyridine tricarboxylic acid—from ring 1.



Metahemipinic acid—from ring 2.



Veratric acid—from ring 3.



Papaverinic acid—from rings 1 and 3.

That papaverine is an isoquinoline derivative is shown by the fact that papaveraldine (*see* above) yields dimethoxyisoquinoline on potash fusion. All these reactions are in accordance with the above formula. Papaverine occurs to the extent of about 1 per cent. in opium. It can be obtained from the mother liquor remaining after the separation of morphine and codeine hydrochlorides (*see* MORPHINE) by precipitation, as dioxalate on addition of oxalic acid; the oxalate is decomposed by calcium chloride, and from the resulting solution of its chloride the papaverine can be precipitated by ammonia, and crystallised from a mixture of alcohol and ether.

Papaw (*Botany*). The edible fruit and leaves of *Carica papaya* (order, *Caricaceæ*) are valued as the source of PAPAIN, a nitrogenous ferment having the power of digesting the fibres of meat. The tree is indigenous to South America, but is now cultivated in many tropical countries.

Paper. On account of modern developments in the process of manufacture, namely, the employment of fibres other than those of cotton and linen, the old definition of paper as a "substance made from rags" must be modified to read "a substance composed of vegetable fibres suitably united or felted together into the form of a sheet." The present method of making paper from rags may be described briefly as follows. The rags, mostly imported from abroad in huge bales, are disinfected by exposure to high pressure steam or to the action of chemical vapours in closed vessels. They are then carefully assorted according to quality and colour; all extraneous matter, such as string, pieces of wood, metal, etc., being removed during the operation. The next process—*viz.* CUTTING—is performed either by hand or by machinery, the better qualities of paper being made from hand-cut rags, which are reduced to pieces about 4 in. square by bringing them into contact with a large knife fixed to a bench. In this form they are passed through a special machine, which knocks out the dust and dirt, and automatically delivers them to the boiler house. Here they are boiled, under pressure, with caustic soda or with lime, in order to remove grease and the non-fibrous constituents of the rags. The better qualities are treated for eight or ten hours with about 10 per cent. of their weight of caustic soda. The removal of the dirty liquid produced is effected by a thorough wash in the rag engine, a machine so constructed that the rags are circulated continuously between the knives of a revolving cylinder and other sharp knives fixed to the bottom of the engine. The rags are thus torn up into separate fibres, while at the same time the dirty water is removed by a contrivance known as a drum washer. The addition of bleach liquor to the pulp in the breaker or rag engine whitens the "half stuff," as the pulp in this condition is called; but in many cases the bleaching is effected in a separate machine known as a potcher, similar in construction to the rag engine. After the complete removal of the bleach liquor residues by thorough washing, the half stuff is more completely torn up or beaten by continuous circulation between a fixed bed plate of knives bolted to the bottom of the beating engine and a rotating beater roll also provided with knives. HAND MADE PAPER: The beaten pulp is now mixed with water in a large deep wooden tank or vat. A mould (a wire cloth fastened to a wooden frame), fitted with a deckle or movable frame forming a raised edge to the wire cloth, is dipped into the vat, and a quantity of diluted pulp lifted out. By a gentle lateral motion imparted to the mould the fibres are caused to interlace or felt together while the water drains through the wire, leaving a wet sheet of paper on the wire cloth. The deckle is removed, and the mould laid upside down on a piece of felt or woollen cloth. A slight pressure applied to the mould causes the wet sheet to adhere to the felt, so that the mould can be removed. A second felt is placed over the wet sheet, and the next sheet formed laid upon it. In this way a pile or post, as it is called, of about 144 sheets is obtained, and this is submitted to great pressure, to take out the excess water. The sheets are hung up to dry, and subsequently sized by immersion in a solution of gelatine, and then again dried. The paper when dry is glazed by pressure between polished plates or by friction between polished rolls, which impart a finished surface to the paper. MACHINE MADE PAPER: In 1799 Louis Robert, a Frenchman, devised a means for making a long sheet of paper on an endless wire cloth. The idea was improved by Fourdrinier, and in 1804 the machine became a practical success. Since this date numerous additions and improvements have been made, so that it is now possible to make the cheaper qualities of paper 144 in. wide at a speed of over 400 ft. a minute. The pulp, after treatment in the beating engine, is discharged into stiff chests (corresponding to the vats used in making paper by hand), and then pumped, mixed with a due proportion of water, along sand traps, which serve to take out mechanical impurities and dirt. It is then screened through brass plates provided with fine slits or cuts, and allowed to flow over a flexible rubber cloth or apron on to the endless wire. By means of a continuous shaking motion the wet pulp felts into a web or sheet of paper, the excess of water falling through the wire. Further moisture is removed by suction or vacuum boxes and by the couch roll, the latter also causing the fibres to felt together more completely. The wet web then passes through press rolls to ensure perfect felting and even thickness, and the paper is dried by passing over hollow cylinders heated internally by steam. It is then formed into large reels. The paper, now in the form of a reel, is passed through a trough containing animal size or gelatine, and led over a large number of skeleton drums, and slowly dried by warm air. A glazed or shiny surface is imparted to the paper, by means of polished rollers, on another machine called a calender. OTHER RAW FIBRES: The removal of excise duty from paper in 1869 soon created a larger demand for paper, and eventually raw materials other than rags had to be found. Those principally used are: (1) STRAW and ESPARTO, each containing about 45 to 50 per cent. of fibrous material suitable for paper-

making. The remainder, consisting of resinous and siliceous matter, is dissolved out in the preparatory treatment. Straw is used largely for cheap papers and box boards. Esparto is used chiefly in book and magazine papers. (2) JUTE AND MANILLA, used for the manufacture of wrappers and strong envelope papers. (3) WOOD PULP, used for all varieties of paper. For details of manufacture *see* WOOD PULP. The pulp, prepared by the chemical process, is suitable for high class papers. A pulp prepared from wood by a mechanical process is only employed for the manufacture of cheap printings and news. The preparatory treatment of the wood involves processes of boiling, breaking, and bleaching similar to those used for rags, although differing in degree. METHODS OF TREATING THE CHEAPER RAW MATERIALS: By blending two or more pulps a great variety of cheaper papers is obtained. Writing papers can be made from rags and chemical wood pulp; magazine and book papers from esparto and chemical wood, cheap printings and news from chemical and mechanical wood. The pulps, suitably blended and beaten, are in the cheaper grades of paper, sized by adding resin size to the pulp in the engine, and not by the use of expensive gelatine. The resin size is made by boiling resin in carbonate of soda. The size is added to the pulp, and then the further addition of alum precipitates the resin on the fibres and renders the pulp partially waterproof. Certain mineral substances, such as China clay, terra alba, etc., are added to the pulp to give weight and to improve the appearance of the paper. The final glazing or surfacing of papers of this class is not always effected on a separate machine. The paper machine is provided with suitable calenders or polished rolls, and the paper glazed as it leaves the drying cylinders. In other respects the manufacture of the cheaper qualities resembles the manufacture of the better machine made grades. VARIETIES OF PAPER: A complete list would fill one or two columns. COLOURED PAPERS are obtained by adding aniline dyes to the pulp in the beater. WATERPROOF PAPER, such as the Willesden paper, is prepared by passing ordinary paper through a bath of cupro ammonium, which acts on the surface of the paper, partially dissolving it. This on drying forms a glazed coating impervious to water. IMITATION PARCHMENT is ordinary paper passed through a bath of sulphuric acid, which has the peculiar effect of toughening the fibres. The acid is washed out and the paper dried in the usual way. TRACING PAPER is ordinary unsized paper coated on one side with a varnish of Canada balsam and turpentine. OILED PAPER for copying books is prepared by brushing over ordinary paper with boiled linseed oil. ART PAPERS used for lithographic printing are made from wood and esparto, coated, after being made, with a mixture of China clay or barytes and glue. DUPLEX PAPERS are coated on each side with a different coloured mixture. HISTORICAL POINTS: The following table is a summary of the more interesting dates in connection with the industry (the early ones being only approximate):

Palm leaves in use before . . .	B.C.	2000
Bark of trees employed about . .	..	2000
Papyrus used as early as	„	2400
Parchment and skins in use about .	„	200
Rice and bamboo used in China about	A.D.	200
Rags known in China before . .	„	700
Rags brought to Europe by the Moors	„	1000
Cotton paper known in England about	„	1300
First mill in England built by Tate .	„	1498
Spielman's mill at Dartford erected .	„	1588
Whatman's mill erected at Maidstone	A.D.	1760
Paper making machine invented .	„	1799
Excise duty on paper removed . .	„	1860
Straw used for making paper . .	„	1851
Esparto introduced by Routledge .	„	1852
Wood pulp, the staple fibre of cheap paper	„	1866

The improvements since 1866 are of a mechanical nature, chiefly relating to speed, output, economy, and other minor details. MODERN BIBLIOGRAPHY: *Papermaking* (Cross & Bevan), *Practical Papermaking* (Clapperton), *Manufacture of Paper* (Davis), *Chemistry of Paper* (Little).—R. W. S.

Paper Cable (*Elect. Eng.*) A cable in which paper is used as a part of the insulating material.

Paper Condenser (*Elect.*) A condenser formed of sheets of tinfoil separated by sheets of paraffined paper.

Paperhanging (*Dec.*) The art of affixing paper and other wall coverings to the surface of walls, ceilings, etc., for the purpose of decoration. The work of a paperhanger now includes hanging (*i.e.* affixing) with an agglutinant, plain and printed paper; pressed or moulded materials having a design in relief, such as Anaglypta, Cordelova, Lincrusta Walton, Cameoid, etc.; canvas hangings, such as Fabrikona; silk mounted on a paper backing, and other materials. The following are the chief varieties of paperhangings in common use:—"PULPS," sometimes called "BLANKS," which are the commonest description of wallpaper made, and have the pattern printed directly on the plain paper. This may be either white or brown, and provides one of the colours which form the pattern. "MACHINES" are papers printed by machines, and comprise a very large variety. In this class of paperhanging the paper is usually first grounded, that is, coloured with distemper colour applied by revolving brushes. The various colours comprising the pattern are then printed by a series of rollers, which are frequently all contained on a single machine, so that the grounded paper enters the machine at one point, passes over the various rollers, and emerges from the other end completely printed, if necessary in as many as a dozen or more colours. It is then taken up automatically in loops or festoons, and carried slowly along the drying room, heated by steam pipes, so that the pattern is quite dry by the time the paper reaches the farther end. Here the long lengths are cut up into rolls and are ready for shipment. "GOLD" or "METAL" PAPERS are those in which bronze or imitation gold leaf occurs, but their use has now declined. "GROUNDS," sometimes called "TINTS," are plain tinted papers without pattern. They are used for plain friezes, ceilings, and for lining cupboards, etc., and are made in a large variety of light and deep colourings. "MICAS" are papers grounded in a composition of which mica, talc, and other similar substances form part, the object being to give an iridescent surface. "SATINS" is a term applied to glazed papers having a smooth polished surface, produced by polishing with French chalk. These papers are usually printed in delicate patterns, and are largely used for drawing rooms, bedrooms, ladies' boudoirs, etc. FLOCK PAPERS have a raised pattern formed by finely shredded wool dusted on an adhesive material in which the pattern is printed. Sometimes silk shreds are used instead of wool; the paper is then called a "silk flock." "SANITARIES" is a term applied to those papers which are printed in oil colours, in contradistinction to distemper.

The best qualities permit of the surface being washed with soap and water. "INGRAINS" are now largely used. They are made by adding colouring matter to the paper pulp, and when closely examined will be found to consist of small hairlike portions more strongly coloured than the remainder. They are used quite plain in various colours, and form an excellent background for pictures. They are also made printed in various patterns, usually of a simple character. Hand stencil friezes are now largely used with ingrains. The objection to all ingrained papers is that, being coloured by dyes, they do not hold their tints well. They are of an absorbent nature, and require considerable care and skill in hanging. Those having a white backing are the best, as they prevent the paste, when applied, soaking through. A piece of English made paper measures 12 yds. long and is 21 in. wide when trimmed, *i.e.* when the marginal selvedge is removed, thus giving an area of 63 sq. ft. or 7 sq. yds. Hence the number of pieces required for any particular room is quickly calculated by ascertaining the total superficial area of the walls, although the exact quantity depends largely upon the size of the pattern, large patterns cutting to waste. French, German, and American papers are now used to a considerable extent at home, and are sometimes made in English lengths and widths. French papers, if not specially produced for the English market, are 9 yds. long and 18 in. wide, and the United States papers are the same width and 8 yds. in length.

The first operation of a paperhanger is to trim the paper. This is often done by means of shears, the roll of paper being held in the left hand and re-rolled as the edge is taken off with the shears held in the right. Various machines and appliances for trimming paper are more or less used, the most successful being one in which the paper is held on a rod and rapidly re-wound on to another rod by a simple system of bands, the edge being removed by two sharp discs held just in the proper place. By means of one of these machines a piece of paper may be trimmed in a few seconds. Another successful appliance for the purpose is used after the paper is pasted. It consists of a metal straight edge having a groove in which runs a small appliance containing a sharp edged revolving wheel. The paper having been pasted, it is folded toward the centre, the pasted surface inward; it is then placed against the straight edge, and is trimmed through the two thicknesses by a single stroke of the handle. The first process in hanging paper is to remove the old paper, if there be any. This is wetted and scraped off, and the plastered surface of the wall is then repaired, where necessary, by means of plaster of Paris. In the cheaper class of property it is a common practice to paper a room without removing the old paper, so that in course of time there may be as many as a dozen different papers on the wall. This is a very dirty and unsanitary practice, and is forbidden in some cities by the local laws. In hanging paper, the safest plan to follow is to strike a vertical line by means of a plumbob, as, if the door or window frame should not be quite perpendicular, it would lead to considerable trouble later. Sometimes the joints of the paper are lapped, that is, only one of the selvedge edges is removed. This mars the appearance of the wall, and in all the best work both edges are trimmed, giving what is known as a "butt joint." The paste used is made of wheat flour mixed with boiling water into a stiff batter and stirred free from lumps. A small quantity of powdered alum is usually added to stiffen the paste and prevent it turning sour. Borax, copperas, or carbolic acid may be used for the same purpose. Formaldehyde is an excellent preservative of paste, and does not discolour the paper as alum is apt to do. The pasted paper is pressed to the wall by means of a clean cloth, but a much quicker way is to use a paperhanger's brush, which has long flexible hairs, and by means of which the paper may be fixed in position with a single sweep of the arm. In high class work rollers of various forms are used to press down the paper at the joints. The various relief materials are as a rule fixed in position by means of paste, to which a little glue has been added. A good deal of judgment is required as to the length of time these materials should remain soaking after the paste has been applied, as, if too much time be given, there is danger of the relief being lost. The old fashioned whitewashed ceilings are rapidly giving place to papered ceilings, special paperhangings being made for the purpose, mostly in a very light pattern and of geometrical design. In other cases relief ceiling decorations are used with excellent effect, although the objection urged against them is that they masquerade as plaster. The chief objection urged against all decoration done in portable material, such as wallpaper, etc., is that they show at a glance that they are not designed specially for the position they occupy. To remove this difficulty various expedients have been tried during recent years, among them being one invented by Mr. Walter Crane, in which the joints, instead of being vertical, were zigzag or irregular, following the patterns in such a manner that they could hardly be seen at all when the paper was hung. Quite a recent production in England, although known in the United States for many years, is the "Crown" frieze. It consists of a frieze design printed in continuation and forming part of the pattern beneath. In this case there are usually three lengths to each roll of paper, and these lengths are sufficiently long to be suitable for even a very high room, the lower portions of course being cut to waste in the case of lower apartments. Another expedient of the same character was brought out in the year 1904 for the first time, and consists of a frieze printed in such a way that the lower portion is intended to be cut away close to the pattern, so that the horizontal line seen in most friezes is absent.—A. S. J.

Paper Joint (*Pattern Making*). A pattern is often built up of a number of small pieces, arranged for convenience of working on a flat surface. To facilitate the removal of the finished pattern, a sheet of paper is first glued to this surface, and the various segments or parts of the pattern are glued on to the paper. When complete, the whole pattern is readily detached from the surface by splitting the sheet of paper.

Paper Mulberry (*Botany*). A Japanese tree *Broussonetia papyrifera* (order, *Moraceæ*) whose inner bark is used in paper making.

Paper Negatives (*Photo.*) Negatives taken on a thin and fine grained paper, which is coated with a sensitive film; for printing the paper is rendered transparent by treatment with oil or wax. *See also* STRIPPING FILM.

Paper Scale (*Eng.*) Various scales printed on paper are used by draughtsmen; they are cheap and convenient for many purposes, though not durable.

Paper Shales (*Geol.*) Very thinly laminated rock of argillaceous composition, in which the layers remind one of the leaves of a book. The structure is due to the slow and intermittent deposition of very fine mud at the bottom of water rarely or never affected by currents.

Paper Varnish (*Dec.*) The varnish used on paper varies in composition according to the quality of work, a mastic varnish being considered best when its high price is not prohibitive. Bookbinders use a colourless varnish made by dissolving three parts of mastic in twenty parts of absolute alcohol and adding one part of bleached shellac. Ordinary paper varnish is made from Australian sandarach and Venice turpentine in the proportion of five of the former to three of the latter by weight, dissolved in methylated spirits. A cheaper grade is made by substituting Burgundy pitch for the Venice turpentine.

Papier Maché. A material manufactured from paper pulp mixed with other substances, *e.g.* size. The pulp is moulded into various utensils and fancy articles, which are then dried and japanned. *See also* STEREOTYPE.

Pappus (*Botany*). An appendage in the form of a ring of hairs or scales round the top of a fruit.

Papyrus. A substance made from the stem of the papyrus plant, and used by ancient nations, more especially by the Egyptians, as a writing material. The name is applied to an ancient manuscript on papyrus.

—— (*Architect.*) The plant was used in the mud and reed construction of the early Egyptians. In later Egyptian architecture conventional representations of it are very common.

Para-Amido-Phenol (*Photo.*) A concentrated solution of this, containing sodium sulphite and a caustic alkali, is sold under the name of "Rodinal." Images developed with it appear quickly, but gain density slowly.

Parabanic Acid (*Chem.*) $\begin{matrix} OC-NH \\ | \\ OC-NH \end{matrix}\!\!>CO.$

Also called OXALYLUREA. A white crystalline solid; decomposes on heating; soluble in water and in alcohol; behaves like a dibasic acid; its alkaline salts are easily hydrolysed to oxaluric acid, $H_2NCONHCOCOOH$. It is obtained by the action of nitric acid on uric acid or bromine and water on uric acid; and synthetically by the action of phosphorus oxychloride on a mixture of urea and oxalic acid.

Parabola. The plane curve produced if a cone be cut by a plane parallel to the slant side of the cone. It may also be defined as the plane curve described by a point which moves in such a manner that its distance from a fixed point, the FOCUS, is always equal to its distance from a fixed straight line, termed the DIRECTRIX.

Parabolic Girder (*Eng.*) A girder whose profile is formed by an arc of a parabola on one edge and a chord of the parabola on the other. This form is of uniform strength, *i.e.* the maximum stress is the same at every section of the girder.

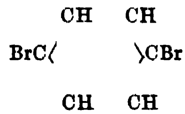
Parabolic Governor (*Eng.*) A governor (*q.v.*) with crossed arms. The path of the balls is approximately a parabola as they fly out from the axis. This form gives a very sensitive governor. *See* GOVERNORS.

Parabolic Mirror (*Light*). A mirror whose principal cross section is an arc of a parabola. Light diverging from a point coinciding with the geometrical focus of the curve forms a pencil of parallel rays after reflection from the surface of the mirror.

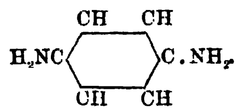
Para Compounds (*Chem.*) The prefix para is used in two ways in chemistry. First, it is used to denote a substance which is a polymer of another substance. Examples: Paracyanogen and para-aldehyde, which are polymers of cyanogen and aldehyde respectively:

C_2N_2 Cyanogen. $(C_2N_2)_n$ Paracyanogen.
C_2H_4O Aldehyde. $(C_2H_4O)_3$ Para-aldehyde.

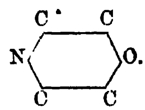
Second, it is used to denote any two diametrically opposite carbon atoms in the benzene ring, and occasionally any two diametrically opposite carbon or other atoms in heterocyclic six membered rings. Examples:



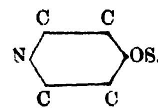
Paradibrombenzene.



Paraphenylenediamine.



Paraoxazine Ring.



Parathiazine Ring.

Paraffins. (*Chem.*) Hydrocarbons of the general formula C_nH_{2n+2}. Examples:

Methane, CH_4	Boils at	$-160°$
Ethane, $CH_3.CH_3$	,, ,,	$-93°$
Propane, $CH_3.CH_2.CH_3$	,, ,,	$-38°$
Butane, $CH_3.CH_2.CH_2CH_3$	,, ,,	$+1°$
Isobutane, $(CH_3)_2CH.CH_3$	,, ,,	$-17°$
Pentane, $CH_3.CH_2.CH_2.CH_2.CH_3$	,, ,,	$+36°$
Isopentane, $(CH_3)_2CHCH_2.CH_3$	,, ,,	$+28°$
Tetramethylmethane, $C(CH_3)_4$	,, ,,	$+10°$

From the 16 carbon atom member upwards they are solids at the ordinary temperature; the highest member yet prepared contains 60 carbon atoms, and melts at 102°. It will be noticed that isomerism begins at the fourth member; the number of isomers rapidly increases with the number of carbon atoms. *See* ISOMERISM. The boiling points of the isomers are always lower than that of the unbranched chain. The isomers are named in several ways: (1) They may be named as derivatives of methane or ethane. (2) They may be named according to the mode of union of the carbon atoms. Where no carbon atom is united to more than two others we have the unbranched chain compound, or normal paraffin, or primary linking. When one or more carbon atoms are linked to three others we have the isoparaffins or secondary linking. When one or more carbon atoms are linked to four others we have the tertiary linking or neoparaffins. (3) They may be named according to the Geneva system. *See* NOMENCLATURE. The paraffins as a class are distinguished by their great stability towards reagents; they burn in air or oxygen, and form substitution products with the halogens, and some of the higher members are

oxidised and nitrated directly by nitric acid. *See* NITRATION. The branched chain members are more readily attacked than the normal members. They are obtained by a variety of reactions, only a few of which can be given: (1) Heating the sodium salt of a fatty acid with soda lime. (2) The alkyl iodides may be reduced by the zinc copper couple. (3) Heating alkyl iodides with sodium, finely divided silver or copper. (4) Electrolysis of the potassium salt of a fatty acid. (5) Heating a fatty acid with hydriodic acid and red phosphorus. The paraffins occur naturally in a variety of ways; but the chief source is the natural or rock oil found in various parts of the world—America, Russia (Crimea and Baku), Galicia, and many other places; they also occur in the tar from the distillation of bituminous shale. *See also* METHANE, PENTANE. The lower boiling liquid mixtures are used for burning and for solvent purposes. *See* FLASHING POINT. The semi-solids are called Vaselines—used as lubricants and salves. The solids are called Paraffin Wax, and are used in candlemaking. *See also* PETROLEUM.

Paragon (*Typog.*) Type of a size between great primer and double pica. *See* TYPE.

Paraguay Tea (*Botany*). *See* ILEX.

Paraldehyde (*Chem.*) *See* ACETALDEHYDE.

Paraleucaniline (*Chem.*) The leuco-compound (*q.v.*) of PARAROSANILINE (*q.v.*)

Parallax. The apparent alteration of position of an object, relative to other objects, when viewed from different points.

—— (*Astron.*) The angle between two lines drawn from a heavenly body to two places from which it can be observed. Parallax is greatest for bodies nearest to the earth, least for the more distant ones, such as the fixed stars.

—— (*Phys.*) An apparent displacement of an object due to its being viewed obliquely; *e.g.* the needle of a galvanometer, etc., will appear to be displaced relatively to the marks on the scale fixed behind it if the observer's eye be not immediately in front of (or over) the needle.

——, **Annual** (*Astron.*) The angular displacement of a fixed star when viewed from different parts of the earth's orbit (*i.e.* at different times of the year). A fixed star is so distant that its direction appears the same when viewed from any part of the earth, *i.e.* it has no Geocentric Parallax; but a small displacement can be observed from opposite sides of the earth's orbit; then taking the diameter of the orbit as a base line and accurately measuring the angles which the apparent directions of a star make with this line at its two ends, the distance of a star can be calculated. The Annual Parallax of fixed stars is very small, rarely much more than 1 or 2 seconds.

Parallax Error (*Phys., etc.*) An error in reading the indications of an instrument, due to PARALLAX (*q.v.*)

Parallel. Two lines are said to be parallel if they lie in the same plane, but will never meet, however far they may be produced. Curves and surfaces are parallel when they are equidistant from each other at every point.

—— (*Elect.*) Two or more conductors are said to be in PARALLEL, PARALLEL ARC, or in MULTIPLE CIRCUIT when one end of each of them is electrically connected to one conductor by which the current enters them all, the other ends being similarly connected to a conductor by which the current leaves them all. If r_1, r_2, r_3, etc., be the resistance of the separate conductors, then their combined resistance R is given by the equation

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \text{etc.}$$

Parallelepiped. A solid bounded by six planes, opposite planes being parallel to each other.

Parallel Gutter (*Build.*) *See* BOX GUTTER.

Parallel Motion (*Eng.*) A form of link work used in beam engines to guide the head of the piston rod in a straight line.

Parallelogram. A four sided plane figure whose opposite sides are parallel.

Parallelogram of Forces, Velocities, etc. If two forces, velocities, or other VECTOR QUANTITIES (*q.v.*) be represented in magnitude and direction by two adjacent sides of a parallelogram, their RESULTANT is represented in magnitude and direction by the diagonal of the parallelogram. Thus if two forces be represented by the sides AB and AD of a parallelogram ABCD, the resultant is represented by the diagonal AC.

Parallel Print (*Foundry*). A CORE PRINT (*q.v.*) made without any TAPER (*q.v.*) This is the case with prints which are to be withdrawn sideways from the mould.

Parallel Ruler *or* **Rule.** A mechanical device used for drawing a number of lines parallel to each other. Its commonest form consists of two flat rulers, joined by two metal links of equal length, so that the four members form the sides of a parallelogram; thus the two rulers always remain parallel to each other.

Parallel Strips (*Carp., etc.*) WINDING STRIPS (*q.v.*)

Parallel Vice (*Eng.*) A vice whose jaws always remain parallel, however far they are opened.

Paramagnetic Substance *or* **Body** (*Elect.*) A substance which when placed in a magnetic field tends to move from the weaker to the stronger part of the field, *e.g.* iron, steel, nickel, and cobalt. Such substances have a PERMEABILITY (*q.v.*) which is greater than unity.

Parameters (*Min.*) The parameters of any crystal plane are numbers which represent the relation of the intercepts of that plane to the intercepts of the unit plane. Thus if the lengths of the intercepts of the unit plane on the axes *abc* were $\frac{1}{2}$, 1, 2, the axial relation of the crystal would be expressed $a : b : c = \cdot 5 : 1 : 2$; and if the actual lengths of some other crystal plane were 1, 1, 1, then the parameters of the second plane would be $\frac{1}{2}$, $\frac{1}{1}$, $\frac{1}{2}$, or 2, 1, $\frac{1}{2}$, or 4, 2, 1, being expressed in the proportional whole numbers. *See* INTERCEPTS.

Paranitraniline Red. *See* DYES AND DYEING.

Parapet (*Architect.*) A low wall constructed for the purpose of protection at the lower part of a roof, or at the sides of bridges, etc. *See* BATTLEMENT.

Parapet Gutter (*Build.*) A gutter constructed behind a parapet wall.

Pararosaniline (*Chem.*)

$$HC\left\langle\begin{matrix}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4NH_2\end{matrix}\right. \qquad HO.C\left\langle\begin{matrix}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4NH_2\end{matrix}\right.$$

Paraleucaniline. Leuco-compound of Pararosaniline. Paratriamidotriphenyl Methane.

Colour Base of Pararosaniline. Paratriamidotriphenyl Carbinol.

$$C\left\langle\begin{matrix}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4:NH_2Cl\end{matrix}\right.$$

Pararosaniline Hydrochloride, commonly called Pararosaniline.

Pararosaniline itself would be $C\left\langle\begin{matrix}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4:NH\end{matrix}\right.$, and is unknown. Its hydrochloride is a dark coloured crystalline solid with lustrous green reflex; sparingly soluble in cold water, more soluble in hot water; soluble in alcohol. Its solutions are red; it is a red dye; with excess of strong acids it forms yellow solutions. It is obtained by the action of hydrochloric acid on the colour base. The latter is obtained in several ways: one of the most important is as follows: A mixture of aniline, paratoluidine, nitrobenzene, iron filings, and hydrochloric acid is heated to about 180°; the iron and acid form ferrous chloride, which is oxidised to ferric chloride by the nitrobenzene; the toluidine is probably oxidised by the ferric chloride to paramidobenzaldehyde, which condenses with two molecules of aniline to form paraleucaniline, which is further oxidised to the colour base of pararosaniline, and the latter forms with hydrochloric acid the dye pararosaniline hydrochloride. The colour base can be synthesised from triphenylmethane by direct nitration with nitric acid, reduction of the trinitro-compound with acetic acid and zinc, and precipitation with ammonia, when the leuco-compound is formed; this on oxidation easily yields the colour base. When the colour base is diazotised with sodium nitrate and sulphuric acid it yields a tridiazo sulphate, which on treatment with alcohol gives triphenylcarbinol, $OH.C\left\langle\begin{matrix}C_6H_5\\C_6H_5\\C_6H_5\end{matrix}\right.$. On boiling with hydrochloric acid it yields paradiamidobenzophenone, $CO\left\langle\begin{matrix}C_6H_5NH_2\\C_6H_5NH_2\end{matrix}\right.$. On heating with concentrated hydriodic acid at 180°—200°, it yields aniline and paratoluidine. A number of important dyes are derived from pararosaniline by introducing alkyl and other groups in place of some or all of the hydrogen atoms of the amido groups. Examples: *Methyl violet* is the hydrochloride of a mixture of penta and hexamethyl pararosaniline. *Crystal violet* is the hydrochloride of hexamethylpararosaniline. *Methyl green* is methyl hexamethylpararosaniline chloride; its salts decompose at about 120°, losing methyl chloride and forming crystal violet.

Para Rubber. *See* CAOUTCHOUC *and* RUBBER.

Paraselenæ (*Meteorol.*) *See* HALOS.

Parasite. An organism which derives its nutriment from other living organisms. Many plants are more or less parasitic in habit, *e.g.* the Dodder and Mistletoe. *Cf.* COMMENSAL.

Parasites (*Foods*). The chief parasites of animals whose flesh is used for food are the: (1) *Tænia solium*, causing the disease known as "measly pork." (2) *Tænia mediocanellata*, which occurs in the flesh of cattle. (3) *Tænia echinococcus*, which infects cattle, swine, and man, through the medium of water or raw vegetables. (4) *Cysticercus cellulosæ*, the cystic form of *Tænia solium*. (5) *Cysticercus bovis*, the cystic form of *Tænia mediocanellata*. (6) *Cysticercus tennicollis*, chiefly infecting sheep. (9) *Cysticercus fisiformis*, found principally in the peritoneal cavities of hares and rabbits. (10) *Distoma hepaticum*, the liver fluke of sheep. (11) *Trichina spiralis*, producing the disease known as trichinosis (12) *Psorospermiæ oviformis*, found in the livers of rabbits, and more rarely in the intestines of cattle and sheep, causing the diseases known as coccidiosis or psorospermosis. (13) *Cœnurus cerebralis*, found in the brains of sheep. (14) *Strongyli rufescens*, found in the lungs of sheep.

Parastata (*Architect.*) A pilaster or anta.

Parchment. The skin of a sheep, goat, or young calf, specially prepared and used for writing, printing, painting, and taking proofs of engravings, etc.

—— **Artificial.** Another name for PARCHMENT PAPER. *See* CELLULOSE.

Parchmentising. The conversion of cellulose fibre (cotton wool, paper, etc.) into a substance termed ARTIFICIAL PARCHMENT. *See* CELLULOSE.

Parchment Paper. *See* CELLULOSE *and* PAPER MANUFACTURE.

Parclose *or* **Perclose** (*Architect.*) (1) A closet. (2) A screen or railing separating a chapel or tomb from the body of a church. (3) A gallery front.

Pardoe Machine (*Print.*) A rotary printing machine invented by Pardoe & Davis.

Pargasite (*Min.*) A variety of HORNBLENDE (*q.v.*) of a greenish colour from Pargas in Finland. *Also called* NOBLE HORNBLENDE.

Parge, Parget (*Build.*) (1) Plaster made of lime and cow dung, used for lining the flues of chimneys. (2) Plaster spread upon a wall or ceiling. (3) A plastered surface with ornamental designs in relief or indented. This last is also known as Pargeting.

Parhelia (*Meteorol.*) *See* HALOS.

Parian Cement. Is composed of a plaster base, the gypsum being mixed with powdered borax. The mixture is calcined and subsequently ground. *See also* CEMENTS.

Parian Marble. *See* MARBLE (STATUARY).

Paring (*Leather*). The paring down of leather to make it thin and suitable for bookbinding, etc.

—— *or* **Scribing Gouge** (*Carp., etc.*) A gouge having the bevel on the inner or concave side of the blade.

Paring Chisel (*Carp. and Join.*) A long and thin bevelled edge chisel. It is used by the pressure of the hand alone, and never struck with a mallet.

Paring Machine (*Chem. Eng.*) A special cutter for trimming the edges of the oil cakes (which are naturally still oily) after the cakes leave the hydraulic press. The parings are re-ground and put into the "kettle" to be treated with fresh seed. *See* OILS.

Paris Green (*Dec.*) A name used in the United States for emerald green (*q.v.*) It is now principally used as an insecticide, particularly for destroying the "potato bug" or Colorado beetle. *See* EMERALD GREEN.

Parkes' Process (*Chem.*) *See* LEAD.

Parlando (*Music.*) In a speaking manner. A somewhat similar direction to *cantando* or *cantabile* (*q.v.*), but more like a recitative.

Parlantes (*Her.*) *See* ARMES PARLANTES.

Parquet Floor (*Carp. and Join.*) A floor composed of thin layers of different woods, usually ½ to 1 in. thick, formed into a pattern. *See also* PATENT PARQUET.

Parsons' Steam Turbine (*Eng.*) *See* STEAM TURBINE.

Part (*Architect.*) *See* MODULE.

—— (*Music*). (1) A voice or instrument, as the tenor part, the violin part. (2) A portion of a composition.

Parthenon (*Architect.*) The name by which the temple of the Goddess Athena Parthenos on the Acropolis at Athens is generally known. It was constructed during the Periclean period (460—400 B.C.) from the designs of Ictinus and Callicrates. The Parthenon is an octastyle peripteral building, having seventeen columns on each flank. The top of the stylobate measures about 101 ft. by 228 ft., and the columns are about 34·2 ft. in height. The cella (*q.v.*) is amphiprostyle, and is divided into two parts: the naos, entered from the east, and containing the statue of the goddess by Phidias; and the opisthodomus, which is separated from the naos and entered from the west. This building is without doubt the finest example of Greek Doric, and is, in fact, generally admitted to be the masterpiece of Greek architecture. *See* ARCHITECTURE, ORDERS OF; GREEK ARCHITECTURE; *and* ELGIN MARBLES.

Partial (*Sound, Music*). The higher tones which are present in a composite tone. *See also* HARMONICS *and* OVERTONES.

Partial Earth (*Elect. Eng.*) A fault in a telegraph line or other conductor consisting of a partial connection with the earth.

Partial Eclipse (*Astron.*) This occurs when the moon does not exactly eclipse the sun, in the case of a solar eclipse; and when the moon does not completely enter the earth's shadow, in the case of a lunar eclipse.

Partially Polarised Light. An admixture of polarised and unpolarised light.

Parting (*Foundry*). (1) The joint between the masses of sand in two boxes in which a mould is made. (2) The formation of this joint. (3) The separation of the different boxes containing a mould, in order to withdraw the pattern.

Parting Bead (*Carp. and Join.*) The bead let into the pulley styles to separate the top and bottom sashes in a cased frame.

Parting Flask (*Met.*) A flask with a small body and long narrow neck, used for dissolving metals in assaying.

Parting Line (*Foundry*). A line (sometimes marked on a pattern) where the surface of the sand in each half of the mould is to come.

Parting Piece (*Carp. and Join.*) The thin slip that prevents the weights rubbing against each other in the boxing of a cased frame.

Parting Ring (*Foundry*). A large ring of iron carrying the upper part of a loam mould. By means of the ring the upper part of the mould can be lifted just as the top part of an ordinary moulding box is lifted.

Parting Sand (*Foundry*). Dry, non-adhesive sand, spread over the surface of the sand where a parting occurs in a mould to prevent the upper and lower parts from adhering.

Parting Tools (*Eng., etc.*) Narrow turning tools used only for cutting through a piece of work (whether wood or metal) in the lathe.

Partizan *or* **Partisan** (*Arms*). A weapon something like a halbert in shape. It consisted of a broad blade fitted on the end of a long staff and having two ornamental projections, one on each side of the blade near the base. Introduced into England in the reign of Edward IV. Subsequently borne by bodyguards as a mark of dignity.

Party *or* **Parted** (*Her.*) A shield divided down the middle is parted per pale. Partition lines parting the shield into ordinaries are thus described: party per fesse, or per bend, or per saltire, etc. *See under* HERALDRY.

Party Line (*Elect. Eng.*) A telephone wire connecting several subscribers or several stations, as distinguished from a line which connects one subscriber only with the exchange. *See also* TELEPHONE.

Party Wall (*Build.*) A wall separating two tenements.

Parvis *or* **Parvise** (*Architect.*) (1) The open space round cathedrals and churches, probably from *paradise* (a garden). (2) A porch or entrance court to a church or other building. (3) A room over a church porch, such as that at S. Wulfram's, Grantham, which contains a chained library.

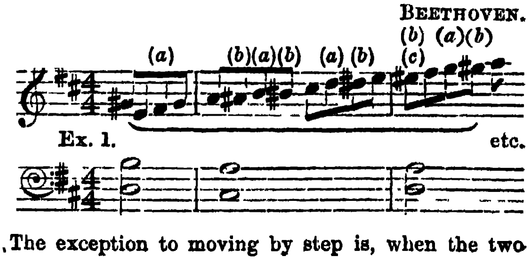
Passed for Press (*Typog.*) A proof with which the author is satisfied is, on being received by the printer, said to be passed for press.

Passiflora (*Botany*). A genus of *Passifloraceæ* (Passion flower family). Several species have edible fruits, such as the Granadilla, Sweet Calabash, and Water Melon.

Passing (*Silk Manufac.*) *See* ENTERING.

Passing Notes (*Music*). Notes foreign to the harmony, but connecting two harmony notes. With the exception given below, they always move by step in the *same* direction from one harmony note to another, and may be either diatonic—Example 1 (*a*)—or chromatic (*b*); but if a chromatic passing note is introduced, the succeeding passing notes should be by step of a semitone till the harmony note is reached. Passing notes may be either on the accented—Example 1 (*c*)—or unaccented parts of the bar (*a, b*).

BEETHOVEN.



The exception to moving by step is, when the two

harmony notes are a third apart the first passing note may leap a third and return to the harmony note, *e.g.*

This is somewhat similar to changing notes, which, however, move round the harmony notes, *e.g.*

Chopin's Pianoforte Étude No. 2 (Op. 10) is full of chromatic passing notes and changing notes.

Passione, Con (*Music*). With passion.

Passive Iron (*Chem.*) *See* IRON.

Passometer (*Surveying*). An instrument recording the *number* of paces taken in walking. The PEDOMETER, which is capable of adjustment to the length of the step, will register the *distance* paced.

Paste (*Chem. Eng.*) A term applied to the solid soap which separates from the leyes after cutting (*q.v.*) It is also applied to all finished soaps which are to be converted into toilet soaps by drying, perfuming, milling (*q.v.*), and plodding (*q.v.*)

—— (*Dec.*) Paperhangers' paste should be made from good wheat flour, the following being the method of mixing: Two pounds of flour are mixed with cold water into a stiff batter; all lumps are beaten out, and the mixture is further thinned with cold water and usually a little alum is added. Borax or formaldehyde are preferable, and alum must not be used if the paste is to be used on papers having delicate colours. Upon the cold batter boiling water is poured, the paste being stirred rapidly until it begins to swell and thicken and to lose some of its whiteness. It is then cooked, but may be further thinned to make it spread easily. It is best not used until cold. When extra strong paste is required a solution of dextrine or British gum should be added. If it is to be used on pressed papers it is usually found advisable to add instead a little glue.

—— (*Elect. Eng.*) The active material (oxide of lead) applied to the surface of the plates or grids in an ACCUMULATOR (*q.v.*)

—— (*Pottery*). *See* HARD PASTE; SOFT PASTE; *and* POTTERY AND PORCELAIN.

Pastel. *See* PAINTING (METHODS).

Paste Points (*Typog.*) A small flat piece of iron, with a pin or spur. It is used for securing register when printing on hand presses. When the appliance is placed in position, the spur protrudes from the tympan and perforates the sheet when the first impression is made.

Pasteur-Chamberland Filter (*Hygiene*). Consists of a metal or glass case containing a tube or "bougie" of unglazed porous porcelain made of kaolin. It is capable of being fixed to an ordinary tap supplying water under pressure—not exceeding two atmospheres—which will force the water through the porcelain cylinders. The resulting filtrate is quite sterile; but it is necessary from time to time to remove the "bougie" and thoroughly cleanse it.

Pasteurisation. *See* MILK.

Paste Wash (*Bind.*) Paste that has been diluted with water; applied to leather bindings to form a suitable surface for the subsequent application of gilt. Glaire (*q.v.*) is applied over the paste wash when the latter is dry.

Pastoral (*Art*). The term applied to pictures after the style of Watteau and Boucher, *i.e.* in which conventional shepherds and shepherdesses figure.

Pastoral Staff (*Her.*) One of the insignia of a bishop and an abbot. They appear on some ecclesiastical shields. *See* CROZIER.

Pasty (*Met.*) Iron is said to be pasty when it is in a viscous condition. This state is made use of in forging, where wrought iron is dealt with; but cast iron which passes through a pasty condition in melting or solidifying is inferior to that which becomes fluid at once.

Pat (*Glass Manufac.*) A flat slab of fireclay, placed on a level with the lower part of the mouth of the pot. Upon this slab the pig rests. *See* POT, ARCH, *and* PIG.

Patchouli (*Botany*). The well known Hindu perfume is obtained by distillation of the leaves of the plant *Pogostemon patchouli* (order, *Labiatæ*). The plant, which is found in Penang, Malacca, and Sylhet, grows to a height of about 2 ft.

Paten. A metal plate or dish, *e.g.* the plate on which the bread is placed in Communion.

Patent Driers (*Dec.*) A paste preparation used for adding to paint to facilitate drying. There are many different formulæ, of which the following is given by Hurst as an example: 15 lb. of dried zinc sulphate, 4 lb. of lead acetate, 7 lb. of litharge ground with 8 lb. of boiled oil. To this mixture is added 100 lb. of Paris white, 50 lb. of white lead, and sufficient boiled oil to make the whole into a stiff paste. Paris white is added in order that the mass shall not harden too rapidly. Much of the patent dryers sold possess very little drying qualities. It is important that these dryers shall not alter the shade of paint with which they are mixed. Manganese salts, *e.g.* the borate, are also used.

Patent Fuel, Briquettes (*Eng., etc.*) Coal dust, etc., mixed with some resinous or gummy substance to act as a binder, and compressed into blocks.

Patent Glazing (*Build.*) There are many kinds of patent glazing, but the principle is the same, *i.e.* there is no putty or other cementing material used, the glass being free to expand or contract. Rendle's "Invincible" and Grover's "Simplex" are well known examples.

Patent Leather. *See* ENAMELLED LEATHER.

Patent Parquet. Wood about $\frac{1}{8}$ or $\frac{1}{4}$ in. thick, of different colours, mounted on canvas by a secret process. At present it is only made in Milan. It has the advantage over ordinary parquetry in being portable, as it rolls up and can be laid like linoleum; while in appearance and wear it is equal to, and undistinguishable from, the old solid laid parquet floor. It forms an ideal hygienic floor covering.

Patent Plate. *See* GLASS MANUFACTURE.

Patera (*Archæol.*) A shallow circular vessel somewhat like a saucer, used by the Greeks and Romans for holding the wine at sacrifices.

—— (*Architect.*) A saucer shaped ornament.

Patetico, Pathetique (*Music*). Pathetic.

Path, Mean Free (*Phys.*) *See* MEAN FREE PATH.

Pathogenic Bacteria. *See* BACTERIA.

Patina. The fine green, semi-transparent crust, consisting of basic copper carbonate, which appears on the surface of copper and bronze when exposed for a length of time to the air. The effect is obtained artificially by immersing copper articles in a bath of acetic acid or other weak acids. The best examples of patina are found on ancient bronzes containing much tin and very little zinc. (2) The mellow tone assumed by the varnish on an oil painting after a lapse of years; the mellow appearance of ancient marble statuary. (3) A shallow bason used by the Romans for domestic purposes. *Cf.* PATEN.

Pattern (*Foundry*). An ordinary pattern is a counterpart in wood of the external form of an object, and is used to form a cavity or mould in sand, which when filled with fluid iron will produce a casting of the required shape. Internal cavities and passages, etc., are not formed on the pattern, but are formed by CORES (*q.v.*) moulded separately and inserted in the mould. A core is held in place by inserting its ends in suitable recesses in the mould. These recesses are produced by projections on the pattern termed Core Prints. Thus a cylindrical hole in a casting will be indicated by two solid projections on the pattern.

Pattern Makers (*Eng.*) The workmen who make the patterns from drawings furnished by the draughtsmen. A pattern maker must possess, in addition to his skill in wood working, an accurate knowledge of the processes of the foundry. The trade is totally distinct from carpentry and joinery.

Pattern Shop (*Eng.*) The part of an engineering works where the patterns are constructed. It resembles an ordinary joiners' shop in appearance and equipment.

Pattinson's Process (*Met.*) *See* LEAD.

Pattinson's White (*Dec.*) A basic chloride of lead obtained by treating chloride of lead with lime. It is white, of good body, but lacks uniformity, and is now almost obsolete.

Paul *or* **Pawl** (*Eng., etc*) A catch or small hinged piece of metal which engages with the teeth of a RATCHET WHEEL (*q.v.*)

Paul Feed (*Eng.*) *See* RATCHET WHEEL.

Pause (*Music*). The sign 𝄐. It denotes that the note or rest over which it is placed is to be prolonged according to the will of the performer (or conductor). If over a bar-line a pause shows that a stop is to be made before proceeding to the following passage, in contradistinction to attacca (*q.v.*) If placed over a double-bar when there has been a "Da Capo," it signifies the end, and corresponds to the word "Fine."

Pavilion (*Architect.*) (1) An isolated edifice such as a small house. (2) A hall of audience in an Eastern palace. (3) A light open structure, such as the building used on a cricket ground for the use of spectators, etc. (4) A strongly marked portion of the front of a building, the roof of which is kept distinct from that of the adjoining work.

Paving (*Civil Eng.*) Covering for a road or footpath which is more durable, less absorbent, and more easily cleansed than a gravelled or macadamised surface. The chief forms are COBBLES, SETTS, FLAGSTONES, WOOD BLOCKS, BRICKS, and various compositions, such as ASPHALT, GRANOLITH, etc.

Paving Tiles (*Build.*) Flat coloured tiles 3 in. to 6 in. square and thicker than roofing tiles.

Paw (*Her.*) The foot only of an animal, generally extended or outstretched.

Pawl. *See* PAUL.

P.D. (*Elect.*) A symbol for POTENTIAL DIFFERENCE (*q.v.*)

Pd. (*Chem.*) The symbol for PALLADIUM (*q.v.*)

Pea (*Botany*). The seeds of this well known food plant, *Pisum sativum* (order, *Leguminosæ*), are highly nutritious, in consequence of the large amount (some 20 to 25 per cent.) of proteid they contain, which is called legumin or vegetable casein. The plant also forms a valuable material for fodder.

Peach. *See* PRUNUS *and* WOODS.

Peach Bloom (*Dec.*) This is not a very definite colour. A mixture usually employed is zinc white added to Venetian red or Indian red.

Peachwood. *See* DYES AND DYEING.

Peacock Blue (*Dec.*) A deep blue of a somewhat greenish hue, but of no definite composition. The usual method is to mix cobalt blue with a little Chinese blue and white.

Peacock Green (*Dec.*) This colour may be made by mixing 50 parts of emerald green, 43 parts of Prussian blue, and 7 parts of white.

Peaked Curve (*Elect. Eng.*) A form of alternating E.M.F. or current in which the curve is steeper than a sine curve. This form of curve indicates that the third partial or component of the curve expressed by Fourier's Series (*q.v.*) is of importance.

Pean (*Eng., etc.*) The PANE (*q.v.*) of a hammer.

— (*Her.*) One of the heraldic furs, the reverse of *erminois*, namely field *sable* powdered *or*. *See under* HERALDRY.

Pea Nut. *See* GROUND NUT.

Pear. *See* WOODS *and* PYRUS,

Pearl (*Typog.*) Type between diamond and ruby in size. *See* TYPE.

Pearl Ash (*Chem.*) *See* ALKALI.

Pearl Essence (*Chem.*) *See* GUANINE.

Pearl Spar (*Min.*) A synonym for Dolomite (*q.v.*)

Pear Push (*Elect. Eng.*) A pendant switch used for electric lights and bells, of which the casing is pear shaped.

Peasemeal (*Foundry*). This is used as a coating on the surface of the sand in complicated moulds; it is afterwards covered with blacking (*q.v.*)

Peat. A deposit of dead vegetable matter which has been left for a long time under such conditions that bacterial action has not been able to bring about the reconversion of the tissues into their original components, CO_2 and water. The factor concerned seems usually to be the continued presence of a thin film of moisture on the dead matter, together with the absence of sunshine. Peat is used for fuel, litter, and also, in a compressed form, as a surgical dressing.

Peck. *See* WEIGHTS AND MEASURES.

Pectolite (*Min.*) A hydrous sodium calcium metasilicate, $H_2O \cdot Na_2O \cdot 4CaO \cdot 6SiO_2$. Pseudo-monosymmetric; usually fibrous, in veins or in radiating masses in basic eruptive rocks. White to

grey or brown. Ayrshire and Midlothian afford many localities. Also from Durham, Skye, Tyrol, New Jersey, etc.

Peculiars (*Typog.*) Accented letters, signs, and special characters for which no provision is made in a compositor's type cases.

Pedal Feed Motion (*Cotton Manufac.*) An attachment to a hopper feeder, and on the skutching machine, for giving a uniform supply of cotton or lap to the beaters.

Pedalier (*Music*). A pedal board (*see* ORGAN) attached to a pianoforte.

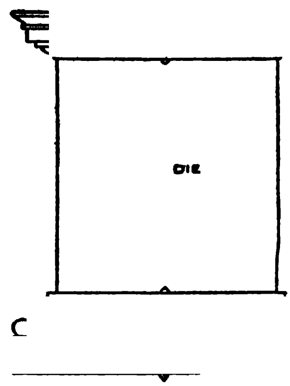
Pedal, Pedal Point (*Music*). A note continued either uninterruptedly or broken by short rests in a part irrespective of the harmonies above or below it. This note may be either at one pitch or changed with its octave. When the pedal is not the lowest part, but appears in an upper part, it is called an *inverted pedal.* The most usual notes for a pedal are the Tonic and Dominant.

Pedals (*Cycle*). *See* CYCLES.

—— (*Music*). (1) The keys of a pedal board. *See* ORGAN. (2) Mechanical contrivances attached to the pianoforte and harp and put into action by the feet. *See* MUSICAL INSTRUMENTS—HARP (*p.* 429) *and* PIANOFORTE (*p.* 431).

Pedersen's Frame (*Cycles*). A light, rigid cycle frame, which has cross stays direct from the top of the head to the bottom bracket.

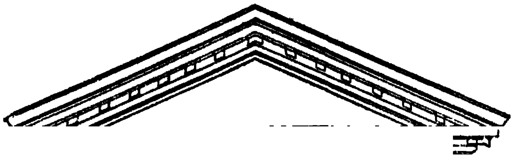
Pedestal (*Architect.*) A feature introduced by the Romans to give greater height to an order without increasing the diameter of the column. It consists of three parts: base; die or dado; cornice or surbase, on which the base of the column stands. The same name is given to a similar form, used to support a statue or other ornament.



PEDESTAL.

—— (*Eng.*) The support or PLUMMER BLOCK serving to support a shaft.

Pediment (*Architect.*) The raking cornices and tympanum forming a termination to the roof of a


PEDIMENT.

classical building. Similar forms are also used over door and window heads in Roman and Renaissance architecture, the same name being given to them.

Pedometer (*Surveying, etc.*) *See* PASSOMETER.

Peel (*Print.*) A contrivance for hanging up printed work to dry on horizontal poles. It consists of a long handle with a broad thin head fitted into one end.

Peeler (*Met.*) *See* RABBLE.

Peeling (*Print.*) *See* OVERLAY.

Peeling of Paint (*Dec.*) This defect is due to insufficient adherence between the paint and the surface to which it is applied. It is most commonly seen where the priming coat is mixed with coarsely ground pigment and an insufficient quantity of oil is used to properly penetrate the wood or cement. Sometimes one coat of paint will peel from another, and to prevent this it is advisable not to allow too much time to elapse between the application of the different coats; in fact, one is best applied over another when the under surface is slightly tacky (*q.v.*)

Peg and Cup Dowels (*Eng.*) Metal DOWELS (*q.v.*) used by pattern makers to connect two parts of a pattern which have to be separated in order to be withdrawn from the mould.

Pegmatite (*Geol.*) A crystalline aggregate of rock-forming silicates, occurring in the form of irregularly lenticular masses traversing gneiss and similar rocks which have been subjected to differential movements at great depths within the Earth's crust while they were in a potentially molten state. Their essential mineral constituents are the same as those of the rock in which they occur; but they are, as a whole, larger grained, which is especially the case towards the centre of the mass. At their outer surfaces pegmatites graduate into the surrounding rock, partly through an interlocking of the crystals on either side of the boundary, and partly through the gradual diminution in the size of the crystals themselves. In no case is there a selvage of finer grained rock along the plane of separation, nor any sharp plane of demarcation between the pegmatite and its enclosing mass, such as exists in the case of most intrusive masses. From this fact it is clear that the rock which encloses the pegmatite must have been at about the same temperature as the latter at the time when consolidation took place. The mineral constitution of pegmatite varies with the composition of the parent rock. In gneisses, or gneissoid rocks allied to granite, the component minerals of the pegmatite are essentially Quartz and the potash felspar Microcline. In the rocks of more basic composition these minerals are represented by Hornblende and the soda-lime felspar Oligoclase. In the case of pegmatites which have been subjected to crushing movements after the earlier stages of consolidation have been passed, some of the Microcline, in the one case, is changed to Muscovite, and part of the Hornblende, in the other, is changed to Biotite. The structure of pegmatite is usually granitic (*q.v.*), as the minerals are generally allotriomorphic (*q.v.*) in relation to each other; but other structures may occur in the acid pegmatites, of which the commonest is that of Graphic Structure. In this, numerous ramifications from large expanses of Quartz crystals closely interpenetrate similar ramifications from equally large expanses of crystals of Microcline. The resulting pattern reminds one of some forms of Oriental writing, whence the name Graphic Granite. Pegmatites are of considerable importance from an economic point of view, not only as ornamental stones, but because such gems as the Topaz and the Emerald occur in them; and because, also, they yield many compounds of the rarer elements, such as Zirconium, Thorium, Cerium, etc.—J. G. G.

Pelagic (*Geol.*) Relating to the deep sea. Correlative with Thalassic and with Littoral, as referring to the conditions under which certain marine strata have been deposited.

Pelasgic (*Architect.*) The art of Greece before the first olympiad (B.C. 776, the beginning of authentic Greek history) is known as Pelasgic art, as it was probably the work of the Pelasgi, the early inhabitants of Greece. The principal remains of Pelasgic art are: (1) Massive walls, formed of rough masses of rock, of rectangular blocks, or of polygonal blocks. (2) Underground chambers, such as the well known "Tholos (or Treasury) of Atreus." This consists of a circular vaulted chamber of stone, about 50 ft. diameter and about the same height, buried under a tumulus, and reached by means of a stone walled passage or dromos (*q.v.*) (3) The Lion Gate at Mycenæ. *See* THOLOS.

Pellet Moulding (*Architect.*) An enriched Norman moulding consisting of a series of small spherical forms in a hollow mould.

Peltier Effect (*Elect.*) If a current flow across the junction of two metals, heat is either absorbed or liberated, according to the direction of the current. The amount of the heat developed or absorbed is proportional to the current, thereby differing from the heat produced in accordance with Joule's Law (*q.v.*)

Pencil. A term sometimes applied to a small camelhair brush. *See* PENCILS.

—— (*Light*). A collection or "bundle" of rays of light, either parallel, convergent, or divergent; a narrow beam of light.

Pencil Gauge (*Join.*) A small piece of wood, notched, and used to guide a pencil when marking a line parallel to the edge of a piece of wood which is to be chamfered.

Pencils (*Dec.*) Small brushes used by decorators and sign writers, of various forms, provided with long handles. When the pencils are held in a quill ferrule the sizes are indicated by the size of quill, such as crow, duck, goose, swan, etc. Red and brown sables, camelhair writers, and short sables are the principal pencils used by the decorator. *See* PAINTERS' BRUSHES.

Pendant (*Architect.*) A hanging ornament used in the roofs and vaults of Perpendicular Gothic architecture. *See* FAN VAULTING.

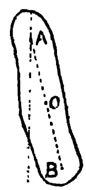
—— (*Build.*) A bracket or apparatus hanging from a roof or ceiling for lighting by gas, etc.

Pendentive (*Architect.*) The portion of a circular dome which descends into a corner of the square over which the dome is constructed. Circular domes are constructed over square spaces in this manner in Byzantine architecture (*q.v.*)

Pendulum. A SIMPLE PENDULUM consists of a heavy particle, suspended by a weightless and absolutely flexible thread. If the pendulum swing through a small arc, the particle will describe approximately a Simple Harmonic Motion (*q.v.*), and the time of a complete vibration is given by the equation

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of the pendulum, and g the acceleration due to gravity. If a rigid body of any shape be free to swing about a frictionless support (*e.g.* knife edges) at A, then it will oscillate in the same time as a simple pendulum of lesser length, AB. The point A is termed the CENTRE OF SUSPENSION, and B the CENTRE OF OSCILLATION. These two points are interchangeable, so that if the body be suspended from B, then A becomes the centre of oscillation. If the body be struck a blow at its centre of oscillation, it will turn about its axis of suspension, but there will be no pressure produced at the axis. From this fact the centre of oscillation is also termed the CENTRE OF PERCUSSION. The time of a complete vibration of a compound pendulum is given by the equation



PENDULUM.

$$2\pi\sqrt{\frac{K}{C}}$$

in which T is the time in seconds, K the Moment of Inertia of the body about the axis of suspension, and C the ratio of the restoring couple exerted by gravity on the body when displaced through a small angle, to the angle through which it has been displaced. Let m be the mass of the body, O the Centre of Gravity, and let the distance $AO = h$; if θ = the angle through which the body is turned, the force due to gravity is mg, acting through O, and its moment about A is $mgh \sin\theta$. Then

$$C = \frac{mgh \sin\theta}{\theta}$$

or $C = mgh$ if θ be a small angle. Let the moment of inertia about an axis through O be mk^2; then the moment of inertia about an axis through A is

$$K = mk^2 + mh^2$$

The time of vibration is therefore

$$T = 2\pi\sqrt{\frac{mk^2 + mh^2}{mgh}}$$

$$T = 2\pi\sqrt{\frac{k^2 + h^2}{gh}}$$

It thus swings in the same time as a simple pendulum of length $\frac{k^2 + h^2}{h}$. KATER'S PENDULUM consists of a bar furnished with two sets of knife edges, one or both of which can be adjusted in position. Positions are found by trial, in which the time of vibration of the pendulum is the same about both knife edges. The distance between the edges is then equal to the length of the equivalent simple pendulum, and if the time of swing be correctly known, the value of g can be obtained with great accuracy. A very small difference in the times of swing about the different knife edges can be allowed for in calculating the results. As the time of swing of a pendulum depends upon its length, it is important in the case of clocks that this shall vary as little as possible; to ensure this result, COMPENSATED PENDULUMS are used. HARRISON'S GRIDIRON PENDULUM has the bob suspended by a framework composed of iron and brass rods, so adjusted in length that the expansion of the brass rods raises the bob as much as that of the iron rod lowers it, the effective length thus remaining constant. In other cases the framework is superseded by concentric tubes of iron and zinc, as in the case of the clock at the Houses of Parliament. In the MERCURIAL PENDULUMS of GRAHAM and DENT the bob consists of a tube containing mercury, whose upward expansion counteracts the downward expansion of the rod.

Pendulum Governor (*Eng.*) The ordinary governor is often so called. The hinged rods carrying the balls are sometimes termed pendulums. *See* GOVERNORS.

Pendulum Spring (*Clocks*). A short thin flexible strip of steel supporting the pendulum, and containing the centre about which it vibrates.

Pene. *See* PANE.

Penetration Twins (*Min.*) Twinned crystals which have no common plane and which mutually penetrate each other. The part in common has a very complex molecular structure, but the free portions retain the symmetrical arrangement. *See* TWINNING.

Penistone Flagstones. *See* BUILDING STONES.

Pennon. A small narrow flag terminating in either one or two points, formerly carried by knights at the end of their lance or spear, and usually bearing a device or the arms of the knight.

Pennyweight. *See* WEIGHTS AND MEASURES.

Penrith Sandstone. *See* BUILDING STONES.

Penstock. A trough or conduit for water, made of boards. The sluice above a water wheel.

Pentachord (*Music*). A succession of five diatonic sounds scalewise.

Pentamethylenediamine (*Chem.*) *See* CADAVERINE.

Pentanes (*Chem.*) C_5H_{12}. There are five compounds of this formula; their names, constitution, and boiling points are given under PARAFFINS. They are all colourless liquids of agreeable smell, and possess the general properties of the Paraffins. Normal pentane burns with a luminous flame, and is used as a standard light in testing the illuminating power of coal gas.

Pentane Standard. A light obtained by burning pentane (*q.v.*) in a particular form of lamp, to serve as a standard of illumination in photometric work. The Harcourt Lamp burns one volume of liquid pentane to 576 volumes of air; the burner is $\frac{1}{4}$ in. diameter and the flame $2\frac{1}{2}$ in. high; the light is then equal to one British Standard Candle (*q.v.*)

Pentaptych (*Art*). A painted or carved panel or screen, consisting of five leaves, which fold over each other. *Cf.* TRIPTYCH.

Pentastyle (*Architect.*) The name given to a temple which has five columns in the front row. *See* HEXASTYLE, OCTASTYLE, DISTYLE, *and* DECASTYLE.

Pentelic Marble. *See* MARBLE, STATUARY.

Pentosans (*Chem.*) Anhydride-like derivatives of the Pentoses.

Pentoses (*Chem.*) Sugars containing five carbon atoms. Examples are arabinose (*q.v.*), xylose (*q.v.*) *See also* SUGARS.

Penumbra. The partial shadow beyond and adjoining the total shadow which is caused by an opaque body intercepting light from a luminous body. In art, the point or boundary at which light blends with shade.

—— (*Astron.*) A half shadow which surrounds the deeper shadow of the earth: the umbra of a sunspot or the shadow of the moon.

Peplum (*Archæol.*) A cloak or shawl longer and of finer material than the pallium (*q.v.*), worn by Greek and Roman women.

Pepper (*Botany*). The dried unripe berry of *Piper nigrum* (order, *Piperaceæ*) constitutes Black Pepper, and, on removal of the rind, White Pepper.

Peppermint (*Botany*). The essential oil is distilled from the leaves of the fresh plant *Mentha piperita* (order, *Labiatæ*). *See* LABIATÆ.

Pepsin (*Chem.*) That constituent of the gastric juice which hydrolyses proteids, converting them finally into peptones; it is a solid precipitated from solution by ammonium sulphate. It contains carbon, hydrogen, nitrogen, oxygen, sulphur; but nothing is known of its chemical constitution.

Peptones (*Chem.*) The final products of hydrolysis of proteids by pepsin; they can also be obtained by hydrolysing proteids by dilute acids or by superheated steam. Soluble in water, insoluble in alcohol, easily diffuse through animal membranes, give the Biuret reaction, give precipitates with the alkaloid reagents, not coagulated by heat.

Per (*Music*). By, as *per recti et retro*, by forward and backward motion. Dr. Crotch's Double Chant in G is a good example, where Part 3 is the reverse of Part 1, and Part 4 the reverse of Part 2 in all four voices.

Percarbonates (*Chem.*) *See* POTASSIUM COMPOUNDS.

Percentage Conductivity (*Elect. Eng.*) The ratio (expressed as a percentage) of the conductivity of a given copper wire to that of a similar wire made of pure copper.

Perching (*Leather Manufac.*) A similar process to staking, but in perching the skin is fixed to a horizontal pole (the perch), and is worked over on the flesh side with a "crutch stake," a tool fixed on a handle like a crutch.

Perchlorates and Perchloric Acid (*Chem.*), R^IClO_4. The perchlorates are salts of perchloric acid. The acid is a white crystalline solid which melts at 15°. It is deliquescent; forms a hydrate with one molecular proportion of water. It decomposes on keeping and with explosive violence on heating or on contact with organic matter. It is obtained by distilling potassium perchlorate with concentrated sulphuric acid. It is a monobasic acid; its most important salt is potassium perchlorate, $KClO_4$. The salt is obtained by heating potassium chlorate till it has lost about a fifth of its oxygen, when it forms a nearly solid mass. The mixture of chlorate, perchlorate, and chloride is washed with water to remove chloride, then warmed with hydrochloric acid to decompose chlorate. From the residue pure potassium perchlorate can be obtained by crystallisation. It is a white crystalline solid, isomorphous with potassium permanganate, sparingly soluble in water, insoluble in absolute alcohol.

Probable constitution, $O = \overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle O}{\|}}{Cl}} - OK$. All other perchlorates are soluble in water. All perchlorates on heating give a chloride and oxygen. They are not reduced by sulphur dioxide.

Perclose. *See* PARCLOSE.

Percussion (*Music*). *See* HARMONIUM, *p.* 442.

——, **Centre of** (*Phys.*) *See* PENDULUM.

Perdendosi (*Music*). Gradually softer and slower.

Perennial (*Botany*). Living more than two years: the term may be applied to a plant as a whole, or to certain parts, *e.g.* the root or stem. A plant whose stem dies down annually, while the roots remain alive, is termed a HERBACEOUS PERENNIAL.

Perfect (*Music*). A term applied to the intervals of the 4th, 5th and octave. Perfect intervals are so called because they are changed from consonant to dissonant intervals when augmented or diminished. This is not the case with the other intervals: 2nds and 7ths are dissonant intervals in both the major and minor form, whilst 3rds and 6ths are consonant intervals in both the major and minor form. *See also* CONCORD *and* INTERVAL. The term is also applied to the cadence having the chord progressions Dominant to Tonic. *See* CADENCE.

Perfect Cadence (*Music*). *See* CADENCE.

Perfect Engine (*Phys.*) A theoretically perfect engine is one which converts a certain definite fraction of the heat supplied to it into mechanical work. If W be the work done, H the heat supplied (measured in mechanical units), θ_1 and θ_2 the absolute temperature of the working substance at the time that it enters and leaves the cylinder respectively, then

$$\frac{W}{H} = \frac{\theta_1 - \theta_2}{\theta_1}$$

Thus, if the working substance enter a cylinder at 200° C. and leave it at 100° C., we have $\theta_1 = 273 + 200 = 473°$, $\theta_2 = 373$, and a perfect engine will convert the fraction $\frac{100}{473}$ of the energy supplied to it in the form of heat into mechanical work. This fraction or ratio is termed the EFFICIENCY of the engine.

Perfecting Engine (*Paper Manufac.*) A conical shaped vessel, fitted internally with revolving knives, used for beating pulp.

Perfecting Machine (*Print.*) *See* TYPOGRAPHY.

Perfect Paper (*Print.*) Reams made up to the full number of 516 sheets.

Perfect Up (*Print.*) Printing the second side of a sheet of paper.

Perforated Bars (*Lace Manufac.*) Thin ribbons of the highest quality of steel, in thickness 100 and upwards to the inch. Holes are pierced in them at certain well defined and accurate distances for the reception of the warp threads. Invented by Mr. (afterwards Sir James) Oldknow to supersede bars with attached guides.

Perforated Bricks (*Build.*) Bricks having a number of holes through them; used for ventilation.

Perforated Pulley (*Eng.*) A pulley whose rim is pierced by a number of small holes; these holes allow the layer of air which is enclosed between the belt and the periphery of the pulley to escape, and bring the belt into closer contact with the metal, thereby diminishing the amount of slip.

Perforator (*Elect. Eng.*) The instrument used for perforating or punching the holes in a paper strip used for transmitting messages by automatic telegraphic instruments (Morse, etc.)

Perianth (*Botany*). The outer floral leaves in the flower. It usually consists of an outer green calyx and an inner coloured corolla.

Pericarp (*Botany*). The term applied to the wall of the ripened ovary in the fruit. In the "stone fruits," such as cherry and plum, it is divisible into three layers: the rind, or epicarp; the pulp, or mesocarp; the stone, or endocarp.

Periclase (*Min.*) Native magnesia, MgO. Cubic, in dark octahedra and greenish grains in metamorphosed limestone from Monte Somma. It usually contains traces of ferrous oxide.

Pericline (*Min.*) A variety of Albite (*q.v.*), twinned in a particular way, in white turbid crystals elongated along the *b* axis.

Peridot (*Min.*) A synonym for Olivine. Peridot is one of the names by which jewellers designate Olivine.

Perigee (*Astron.*) The Sun (or Moon) is said to be in Perigee when its distance from the Earth is least. *Cf.* APOGEE.

Perihelion (*Astron.*) The position of the earth, planet, or comet when nearest to the sun.

Period (*Music*). A complete musical sentence divided into two parts at least, the former of which generally ends with a half close or some form of middle cadence, and the latter with a full cadence. The subdivisions are called phrases.

—— (*Phys.*) The time occupied by a complete movement or cycle of operations; *e.g.* the time of swing of a pendulum, or the time taken by a complete alternation of an alternating electric current.

Periodates and Periodic Acid. (*Chem.*) The normal periodic acid HIO_4 is an unstable solid obtained by heating orthoperiodic acid at 100° under very low pressure (15 mm.); it decomposes on further heating into the pentoxide, water, and oxygen, without forming the heptoxide I_2O_7 which corresponds to this acid. Orthoperiodic acid, H_5IO_6, the common acid, is a white crystalline solid which melts at 133°, and decomposes at 140° like the normal acid. It is obtained from its disilver salt $Ag_2H_3IO_6$ by acting upon it with water, $5Ag_2H_3IO_6 = 3H_5IO_6 + 2Ag_5IO_6$. Many periodates are known, and they can all be regarded as derived from various hydrates of the heptoxide I_2O_7:

$$I_2O_7 + H_2O = 2HIO_4$$
Metaperiodic Acid (Normal Acid).

$$I_2O_7 + 3H_2O = 2H_3IO_5$$
Mesoperiodic Acid.

$$O = 2H_5IO_6$$
Orthoperiodic Acid.

Sodium orthoperiodate is obtained as a sparingly soluble solid by passing chlorine into a mixture of sodium iodate and hydroxide dissolved in water:

$$Na_2I_2O_6 + 6NaOH + 2Cl_2 = 4NaCl + 2Na_2H_3IO_6.$$

The silver salt referred to above can be obtained by suspending this sodium salt in water; add just enough nitric acid to dissolve it and then silver nitrate, when the pale yellow disilver hydrogen periodate separates. The salt Ag_5IO_6 is a black crystalline powder. The periodates when heated give oxygen and an iodide.

Periodic Current. An ALTERNATING CURRENT.

Periodicity (*Phys., Elect. Eng., etc.*) The FREQUENCY (*q.v.*) of any recurring operation.

Periodic Motion (*Phys., etc.*) A motion which is repeated in definite regular intervals of time, *e.g.* the swing of a pendulum or the vibrations of a sounding body.

Periodic Perturbations (*Astron.*) Slight disturbances in the position of the Earth in its orbit which take place periodically.

Periodic System. A method of arranging the elements so as to exhibit their properties as a periodic function of their atomic weights. All the commoner elements are included in the subjoined Table 1, arranged in the order of their atomic weights. A very few of the less common elements are included for reference. Where dashes occur, rare elements are known which take these places; where no element and no dash occur, there is either no element known at all or the place has been assigned to some imperfectly studied element. Hydrogen is omitted, as it does not fit into any group at the present time. The vertical rows will be referred to as SERIES, the horizontal rows as GROUPS. A group contains allied elements. Each group can be divided into two SUB-GROUPS, each containing elements more closely allied to each other than they are to the other members of the group. For example, in Group II. Calcium, Strontium, Barium are very closely allied to each other, and they constitute the odd series; while Magnesium, Zinc, Cadmium, and Mercury are fairly closely allied; and there is a general resemblance between all the members of the group. The elements are also arranged fairly well according to their valency, as the table shows.

	1	2	3	4	5	6	7	8	9	10	11
I.	Li 7	Na 23	K 39	Cu 63	Rb 85	Ag 108	Cs 133			Au 197	
II.	Be 9	Mg 24	Ca 40	Zn 65	Sr 87	Cd 112	Ba 137			Hg 200	Ra 225
III. A	B 11	Al 27	—	—	—	—	—			—	
IV.	C 12	Si 28	Ti 48	—	—	Sn 119	—			Pb 207	Th 232
V.	N 14	P 31	—	As 75	—	Sb 120				Bi 208	
VI.	O 16	S 32	Cr 52	Se 79	—	Te 127·5			—		U 238
VII.	F 19	Cl 35·5	Mn 55	Br 80	—	I 127					
VIII.	B		Fe 56 Ni 59 Co 59		Ru 102 — —		C		— — Pt 195		

TABLE 1.

FORMULA.

	(*a*) Of Oxides.	(*b*) Of Chlorides.
Group I.	R_2O	RCl
II.	$*R_2O_2$	RCl_2
III.	R_2O_3	RCl_3
IV.	RO_2	RCl_4
V.	R_2O_3, R_2O_5	RCl_3, RCl_5
VI.	R_2O_2 RO_3	RCl_2, RCl_6
VII.	R_2O, R_2O_7	RCl, RCl_7

When a curve is drawn having atomic weights as abscissae and melting points as ordinates, a series of alternate minima and maxima are obtained, and the elements which form the minimum and maximum points are all in Groups I., IV., VII., or VIII. Example:

Minima Li F Cl Br Cs
Maxima C Si Mn Ru

In the first two series the maxima are in Group IV.; these two series are called SHORT SERIES; series 3 and 4, 5 and 6, 9 and 10 are called LONG SERIES, and between the two series which compose a long series are the so-called TRANSITIONAL ELEMENTS—groups of three elements, the members of which are closely allied to each other. Besides the periodicity of the melting point, the atomic volumes of the elements vary periodically with the atomic weights, and in such a way that generally the atomic volume is a minimum where the melting point is a maximum, and *vice versa*. Other properties of the elements are also more or less periodically variable with the atomic weights, such as the heat of formation of the halogen salts; also the spectral lines of elements in the same group show relationships, *e.g.* those of Magnesium, Calcium, and Strontium, and those of Zinc, Cadmium, and Mercury of Group II. The system also divides the elements into metals and non-metals fairly well; if a triangle be drawn between the points A, B, C in Table 1, it includes the Non-Metals and two metals Chromium and Manganese (as Table 2). Chromium resembles the non-metals in its trioxide and compounds derived from it, and manganese in forming permanganates which are isomorphous with the perchlorates. The new elements of no valency must be regarded as forming transitional elements between the strongly basic elements of Group I. and the strongly acid elements of Group VII.; thus before Lithium comes Helium, and between Fluorine and Sodium comes Neon, between Chlorine and

Potassium Argon, between Bromine and Rubidium Krypton. The system is not by any means perfect. Tellurium must be placed in Group VI., although it has a higher atomic weight than iodine; Manganese is out of place in Group VII.; Argon must be placed before Potassium, although it has a higher atomic weight than the metal. The periodic system has been of use in controlling atomic weights and in predicting the existence and even the properties of new elements. Many attempts have been made to account for the periodicity of the properties of the elements; one of the most recent of these, due to Professor Emerson Reynolds, will be found in the Chemical Society's *Journal* for 1902, p. 612; an account of the most recent attempt, due to Professor J. J. Thomson, will be found in *The Recent Development of Physical Science*, by W. C. D. Whetham, p. 258.

A

III.	B 11					
IV.	C 12	Si 28				
V.	N 14	P 31	—	As 75		
VI.	O 16	S 32	Cr 52	Se 79	—	
VII.	F 19	Cl 35·5	Mn 55	Br 80		I 127

B

TABLE 2.

Peripheral Velocity. The linear velocity (*q.v.*) of a point in the circumference of a revolving wheel, etc., as distinguished from the angular velocity of the wheel.

Peri-Position (*Chem.*) *See* NAPHTHALENE.

Peripteral (*Architect.*) The name given to that form of temple which is surrounded by a range of columns. *See* PSEUDO-PERIPTERAL.

Periscope (*Optics*). An optical device by which a view in a horizontal direction may be obtained by looking through a vertical tube. Such a device is used on submersible boats to enable a look out to be kept when running just below the surface of the water.

Periscopic Lens (*Light*). A MENISCUS LENS (*q.v.*)

Peristerite (*Min.*) A variety of albite showing a play of colours.

Peristylium (*Architect.*) A court or square having a colonnade on each of its four sides. This colonnade and also a colonnade surrounding a temple are known as peristyles. In a Roman house the peristylium is the inner court, and, like the atrium, the central part of it is open to the sky. *See* COLONNADE, PORTICO, *and* PTERA.

Perkins' Reaction (*Chem.*) Aromatic aldehydes undergo condensation with sodium salts of fatty acids in presence of the anhydride of the acid. This is Perkins' Reaction. The acid anhydride withdraws water from the aldol compound formed by the union of the aldehyde and fatty acid salt. Example:

$$C_6H_5C\left\langle\begin{matrix}O\\H\end{matrix}\right. + CH_3COONa = C_6H_5C\left\langle\begin{matrix}OH\\CH_2.COONa\\H\end{matrix}\right.$$

Benzaldehyde. Sodium Acetate.

$$C_6H_5C\left\langle\begin{matrix}OH\\CH_2COONa\\H\end{matrix}\right. - H_2O = C_6H_5CH = CH.COONa.$$

Sodium Cinnamate.

The reaction has received many applications; dibasic acids may be used as well as monobasic acids, and the acid anhydride need not be that corresponding to the acid salt. Other examples will be found under COUMARIN and NAPHTHALENE.

Perlite (*Chem., Met.*) *See* IRON.

—— (*Geol.*) A variety of vitreous rock of eruptive origin which has cooled in such a manner as to form a series of curved cracks, which break the rock up into small spheroids, the "pearls."

Permanent Hardness. *See* WATER, CALCIUM COMPOUNDS, *and* CLARK'S PROCESS.

Permanent Load (*Eng.*) (1) A load on any structure which is unvarying in amount or position. (2) The constant work performed by an engine or motor.

Permanent Magnet. *See* MAGNET.

Permanent Set (*Eng.*) When any body is strained beyond its elastic limit (*q.v.*), and therefore does not recover its original form or dimensions when the stress is removed, it is said to have received or acquired a permanent set.

Permanent Way (*Civil Eng.*) The ordinary railway track, consisting of BALLAST, RAILS, and SLEEPERS, laid on a properly prepared surface or formation level. *See also* RAILWAYS.

Permanent Way Crane (*Eng.*) A crane mounted on a railway track. Used for repairs to a line and removal of debris after an accident.

Permanent White (*Dec.*) The best quality of artificial barytes or blanc fixe (*q.v.*), which, when ground in water, is quite permanent. When used in oil, one part is mixed with two parts of oxide of zinc (*q.v.*)

Permanganates (*Chem.*) *See* MANGANESE COMPOUNDS.

Permeability, Magnetic (*Elect.*) The ratio between the number of lines of force (per unit area) running through a piece of magnetisable material—*i.e.* the MAGNETIC INDUCTION B—and the MAGNETISING FORCE H which produces them. The permeability μ is thus given by the equation

$$\mu = \frac{B}{H}$$

For non-magnetic materials B is practically unity. For iron, etc., its value varies very greatly, and depends on the magnetisation, decreasing as the latter increases. It is also affected by the previous treatment of the iron. The following values of the

permeability for different values of B are given by Hopkinson for a good specimen of annealed soft iron;

B	
5,000	3,000
10,000	2,000
15,000	526
20,000	30

Permeameter (*Elect. Eng.*) A simple form of instrument for measuring the PERMEABILITY (*q.v.*) of a bar or rod of iron.

Permeanance (*Elect.*) The reciprocal of the RELUCTANCE (*q.v.*)

Permian (*Geol.*) A series of rocks in which the prevailing colour is red, occurring in the kingdom of Perm, in Russia, and usually regarded as pertaining to a geological horizon intermediate between that of the Carboniferous and the Trias. The rocks in Britain called by this name belong partly to the Carboniferous Rocks (stained red by infiltration of iron from the New Red Rocks), partly to a separate formation, which forms the lower part of the New Red Rocks, and is virtually conformable to the overlying Trias, and at the same time is violently unconformable to all the rocks older than itself. This formation was for a long time called the Lower New Red, or Dyas, and the former name is now coming again into general use. Where the Lower New Red is typically developed, as in North Westmorland, it consists of three members: the Penrith Sandstone, with associated breccias at the base (all of desert origin); above that, the Plant Beds and Marl Slate; and, finally, the Magnesian Limestone. The Bunter Marls which succeed belong to the Trias, and lie with a slight unconformity upon the beds below. In Germany, where these rocks attain considerable commercial importance on account of the occurrence in them of Gypsum and Rock Salt, copper is worked in the Marl Slate, which lies upon the Unter Rotheliegende, one of the higher members of the Upper Carboniferous Rocks of those parts. The most conspicuous member of the so-called Permians in Britain is the Magnesian Limestone, which yields an interesting suite of marine fossils. In the Alps and in the Mediterranean countries the equivalents of the Lower New Red, Dyas, or "Permian" are of marine origin, and yield, amongst other fossils, a large number of species of the earliest types of Ammonites.

Pernot's Revolving Furnace (*Met.*) A furnace with a flat but slightly sloping hearth, which revolves slowly, thus thoroughly mixing the molten metal and exposing it to the action of the flames. It is used on the Continent for steel making by an OPEN HEARTH PROCESS (*q.v.*) *See also* METALLURGY.

Perpendicular. (1) At right angles to a line or plane. (2) Often used as synonymous with VERTICAL.

—— (*Architect.*) One of the periods into which English Gothic architecture is divided. It extended from about 1377 A.D. to 1547 A.D., and is also known as RECTILINEAR GOTHIC. The work of the later part of the period is known as the TUDOR STYLE or FLORID GOTHIC. The principal features of the work of the Perpendicular period are: (1) SHALLOW MOULDINGS, with casements, bowtells, and double ogees. The characteristic ornaments are the Tudor Flower and the Tudor Rose. (2) OCTAGONAL CAPITALS are used with circular shafts, and pier mouldings are frequently carried up into the arch without the intervention of a capital. (3) PANELLING, extensively used on wall surfaces, particularly late in the period. (4) The WINDOWS are very large, frequently taking up almost all the width between the buttresses. Tiers of transoms are used, and the mullions are carried up vertically to the window arch. (5) The TRIFORIUM is reduced to a minimum. (6) The ARCHES are frequently very depressed later in the style, the four-centred arch being a common form. (7) The BUTTRESSES are of large projection, flying buttresses being extensively used. (8) The type of VAULTING used in this style, known as fan vaulting, was a complete departure from the forms which obtained in the preceding periods. (9) The FOLIAGE is of a more conventional type than that of the Decorated period. *See* DECORATED.

Perpends (*Build.*) The vertical joints on the face of brickwork.

Perron (*Architect.*) A French term denoting (1) an external flight of steps at the entrance to a building, giving access to a storey which is raised above the level of the ground. (2) A balcony landing in a similar position with a flight of steps at each end.

Perseids (*Astron.*) A shower of meteors or shooting stars which appears to "shoot" from the constellation of Perseus. The shower recurs every year in the month of August.

Persian (*Leather*). Sheep and goat skins tanned in India with Turwahr bark are imported in large quantities to this country, and are known as PERSIAN SHEEP or PERSIAN GOAT.

Persian Green (*Dec.*) A name sometimes used in connection with Oriental decoration to designate the pure, bright, or vivid green known in the form of a pigment as "emerald green" (*q.v.*) It is almost identical in hue with the primary green in the solar spectrum.

Persians (*Architect.*) *See* ATLANTES.

Persienne (*Build.*) A frame or shutter attached to the outer side of a window, and having slips of wood fixed in the same way as a louver board (*q.v.*)

Personal Equation (*Phys., etc.*) An error due to the idiosyncrasies of a particular observer or experimenter. In a trained observer this error becomes nearly constant, and can be eliminated or accurately allowed for in calculations based on the observations.

Perspective (*Art*). The art of representing by a drawing made on a flat surface solid objects or surfaces not lying in the plane of delineation; the representation of objects as they appear to the eye. In painting, the art of conveying the impression of depth and distance by correct drawing and judicious colour tones and shadows.

——, **Ærial.** The suggestion or expression of distance in a picture by the medium of atmosphere. "The expression of space."—*Ruskin.*

——, **Linear.** The branch of perspective that deals with form and magnitude.

Persulphates and Persulphuric Acid (*Chem.*) *See* POTASSIUM COMPOUNDS *and* SULPHUR COMPOUNDS.

Perturbations (*Astron.*) Variations in the path or orbit of a planet, due to the attractions of other bodies as they approach or recede.

Pesante (*Music*). Heavily, firmly.

Pestle (*Paint.*) An instrument, generally in the form of a truncated cone, the base being a plane surface. Used for grinding pigments.

Pet Cock (*Eng.*) A small tap fitted to the ends of cylinders in steam engines to enable water to escape before the engine is started.

Peterhead Granite. *See* BUILDING STONES.

Petersburg Standard (*Carp. and Join.*) A measure of timber. 120 pieces 12 ft. × 11 in. × $1\frac{1}{2}$ in. = 165 cubic ft.

Petit's Wheel (*Chem. Eng.*) Used in stearine manufacture. A jacketed drum cooled by the circulation of refrigerated brine. The lower portion of the drum dips into a bath of melted fatty acids, and, as it revolves, crystals of stearine separate and are removed before the periphery passes into the bath again. Compare SEEDING.

Petrol. *See* PETROLEUM.

Petrol Engine *or* **Motor.** Under this term are included engines in which the motive power is obtained by the combustion or explosion in the cylinder of vapour derived from an oil or spirit of a more volatile nature than those used in Oil Engines proper (*q.v.*) As such engines are very frequently driven by the mixture of light oils known in the trade as petrol, the name Petrol Engine or Motor has been commonly applied to them in England and France; in the United States they are more often termed Gasoline Motors. They are distinguished from oil engines by the much greater speed at which they run, their consequent smaller size (for any given horse power), and their adaptability to circumstances in which great portability is essential In the most usual types there is no bedplate, the cylinder being bolted to a crank case, which also carries the bearings of the crank shaft.

The main principles of the construction of a small motor (such as is used on motor cycles) are shown in fig 1, which represents a cross section of a single cylinder engine with air cooling; a side view is given in fig. 2. A is the cylinder, in which moves the piston B; the connecting rod C is attached to the piston by a cross head D, and to a crank formed by a pin E, which is fixed to the two wheels F, F. These wheels form the flywheels of the engine, and are mounted on a divided shaft, of which the two halves G and H are supported in bearings in the side of the crank chamber K. The latter is often composed of aluminium castings, bolted to the cylinder at L, and attached to the frame by a lug M. The shaft G carries the pulley by which motion is transmitted to the driving rim of the back wheel of the cycle. The shaft H transmits motion to the HALF SPEED SHAFT N through a pair of toothed wheels O, which cause N to revolve at half the speed of H. The half speed shaft carries two cams, P and Q, shown on a larger scale in fig. 4. The cam P acts on the rod R, and opens the EXHAUST VALVE S, which is closed again after the cam passes the position in which it engages the end of R by a spring on the valve rod. T is the ADMISSION VALVE, also kept closed by a spring on its spindle; U is the SPARKING PLUG (given on a larger scale in fig. 5). The cylinder A and cylinder head V are provided with projecting ribs, which afford a large radiating surface, by means of which the cylinder is cooled. The tube W communicates with the VAPOURISER or CARBURETTOR, in which the explosive mixture is produced, by mixing vapour derived

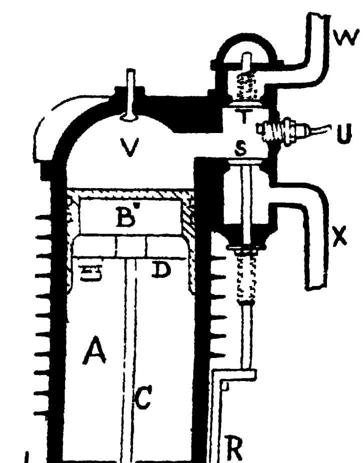


Fig. 1 —Air Cooled Engine (Section).

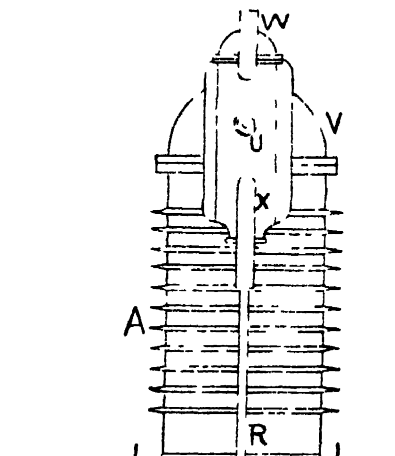


Fig. 2 —Air Cooled Engine (Elevation).

FIGS. 1, 2 —SECTION AND ELEVATION OF SINGLE CYLINDER AIR COOLED MOTOR.

A. Cylinder.
B. Piston.
C. Connecting rod.
D. Cross head.
E. Crank pin.
F. Flywheels.
G, H. Crank shaft
K. Crank case.
L. Joint between crank and cylinder
M. Supporting lug.
Half speed shaft.
Gear wheels.
Cam actuating exhaust valve.
Cam of contact breaker.
Rod for raising the exhaust valve.
S. Exhaust valve.
T. Admission or inlet valve
U. Sparking plug.
V. Cylinder head, containing clearance or compression space.
W Inlet pipe.
X. Exhaust pipe.

from petrol or motor spirit with air; this apparatus is either a SPRAY CARBURETTOR or a SURFACE CARBURETTOR (*q.v.*) X is the EXHAUST PIPE leading to the SILENCER, a chamber from which the products of combustion escape into the air through a number of openings. This arrangement deadens the sound produced by the sudden release of the gases. The action of this engine is as follows: At the commencement of the cycle or series of operations the valves S and T are both closed; the piston descends, and the vacuum created in the clearance space V causes the valve T to be opened by the pressure of the mixture (*i.e.* the explosive gas) in the tube W. The CHARGE of explosive gas is thus drawn into the cylinder during the descent of the piston; as the latter approaches the end of its stroke the valve T closes, and during the up stroke, which is the second stroke of the cycle, the mixture is compressed, both valves remaining closed. As the next down stroke (the third stroke of the cycle) commences, the mixture is fired or ignited by a spark produced at the gap between the projecting wires at the end of the sparking plug U. The explosion causes an impulse to be given to the piston, which moves downward, performing its WORKING STROKE. At the end of this stroke the shaft N has turned round into such a position that the cam P engages the end of the rod R, which it raises, and so opens the exhaust valve S. During the second up stroke (or fourth stroke of the cycle) the products of combustion escape by the pipe X, and at the end of the stroke the cam P ceases to act on the rod R, which drops back into its original position, and the valve S closes, ready for the cycle of operations to begin over again. The production of the spark requires further explanation. A diagram of the electrical connections is given in fig. 3. A is the accumulator, usually consisting of two cells, giving an E.M.F. of about four volts when charged. From one terminal of this a wire goes to one terminal B of the primary of an induction coil (*q.v.*), from the other terminal of which C, a wire, leads to D, where the current enters the CONTACT BREAKER (fig. 4). It now flows from D along an insulated conductor H to the platinum tipped screw E, at which point the circuit has to pass from the

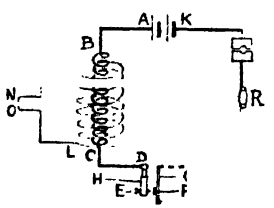


FIG. 3.—DIAGRAM OF ELECTRIC CIRCUIT.

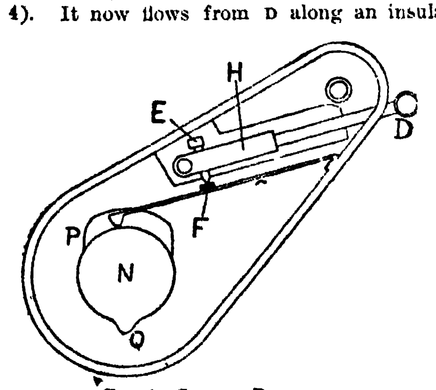


FIG. 4.—CONTACT BREAKER.

screw to the TREMBLER or spring G, on which is fixed a small platinum contact piece F. Between E and F there is a small gap, across which the current is unable to pass until the trembler is raised by means of the cam Q on the half speed shaft. The position of the cam is so adjusted that the contact is made at the time when the working stroke of the engine is commencing. At this instant the current can flow from E to F, through the trembler G, and through the frame of the machine to a switch R (fig. 3) contained in one of the handles of the machine. From this switch an insulated wire carries the current through a plug switch J back to the terminal K of the accumulator, thus completing the primary circuit. The secondary circuit, in which the spark is actually produced, is simpler; M and L are the terminals of the secondary of the induction coil, and are connected to the two platinum wires N and O of the SPARKING PLUG shown on an enlarged scale in fig. 5. A well insulated wire from one terminal of the secondary, L, runs to a metal cap A, fixed at the end of a porcelain cylinder B; through this runs a wire, terminating in the bent elbow O. The plug has a metal mount C, by means of which it can be screwed into the aperture provided at the head of the cylinder (fig. 1). This metal carries the other wire N, which is therefore connected to the engine and frame of the machine, through which the secondary circuit is completed. The portions of both circuits which are formed by the frame are shown in fig. 3 by broken lines. The primary current, which only commences to flow when the circuit is completed by the movement of the contact breaker, is interrupted suddenly when the cam Q (fig. 4) releases the end of the trembler G, and this sudden interruption of the primary current induces an electromotive force in the secondary circuit, which is sufficiently high to cause a spark to leap across the gap N O between the wires of the sparking plug. The primary current can be cut off entirely, and the sparking stopped either by the handle switch R (fig. 3) or by the plug switch J. When the rider dismounts for a time, or leaves the machine, it is usual to take out the plug from the latter switch and keep it in the pocket; in the absence of the plug the current cannot be accidentally turned on. The exact instant at which the spark occurs is of great importance. When the engine is running fast, ignition must occur earlier than when running slowly. The timing of the spark is effected by turning the contact breaker through an angle by means of a rod attached at one end to the case of the contact breaker, and at the other to a small handle placed within easy reach of the rider. *See* MOTOR CYCLES. By this means the cam Q (fig. 4) comes into contact with the spring G earlier or later, as may be required, and therefore the time at which the spark occurs can be controlled.

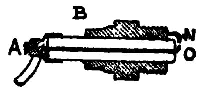


FIG. 5. SPARKING PLUG.

Larger engines are constructed on a somewhat different plan, though the main principles are essentially the same. Two or four cylinders are often employed, or in some cases even more. Diagrams of a two cylinder engine (De Dion type) are given in figs. 6 and 7. The cylinders are each surrounded by a water jacket or space through which flows water, shown by dotted lines. From the jackets the water is led by pipes to a RADIATOR or cooler, an arrangement of tubes provided with external gills of metal, whose function is to increase the radiating surface. The water is then returned to a tank or reservoir,

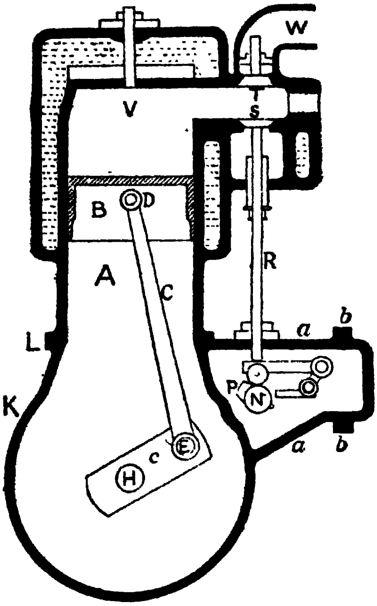


Fig. 6.

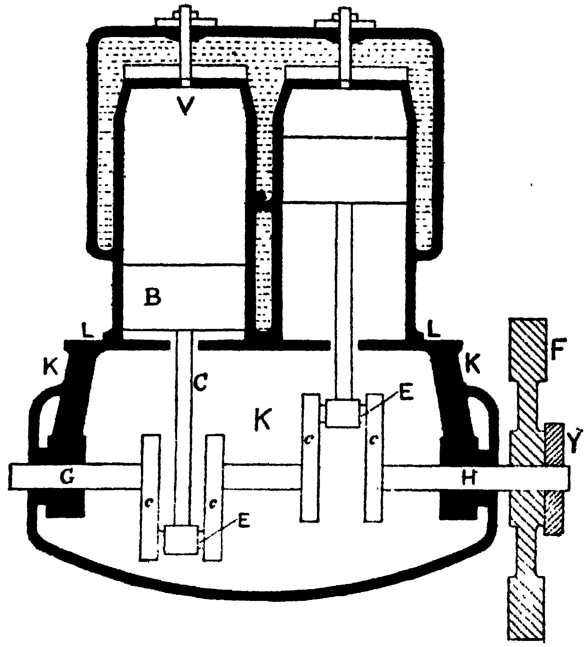


Fig. 7.

Two-Cylinder Water-Cooled Engine.

from which it again flows to the water jackets, the flow being maintained in most cases by a pump worked by the engine. The cranks *c*, *c* are forged or built up, and the flywheel is fixed on a projecting end of the crank shaft outside the cylinder. There is no driving pulley, but the power is transmitted either by some form of clutch Y (fig. 7) or in other cases by gearing on the crank shaft. The half speed shaft N is contained in a chamber *a*, *a* outside the crank chamber K, and carries two separate cams, one to each cylinder. Each cam actuates the rods, which open the corresponding exhaust valve of the cylinder to which it belongs. Access to the chamber can be obtained by removing the cover, which is bolted on by lugs *b*, *b*. The arrangements for producing the spark differ somewhat from those in a single cylinder engine. The commutator is shown in fig. 8. A is the half speed shaft, carrying a cam plate B, provided with two projections C and D, and two recesses E and F. The cams engage the two ends of a rocker G, which carries a spring H, on which are platinum contact pieces at K. In the position shown the cam C is in action, displacing the spring or trembler H till it makes contact with the insulated terminal L. After a quarter of a revolution, C will have moved into the position now occupied by D, and

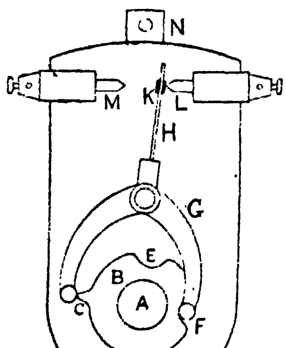


Fig. 8.—Contact Breaker of Two-Cylinder Engine.

the latter will have engaged the other arm of the rocker at F, bringing the spring H into contact with the terminal M. Two coils are used, one end of the primary of each being connected to each of the terminals M and L, and the secondaries to the sparking plugs of the respective cylinders. The spark is timed by turning the contact breaker by means of a lever attached to the lug N, as in the case of the one cylinder engine previously described.

Petrol engines are also constructed to work with a Two Stroke Cycle. They are somewhat less efficient than the four stroke type, but may be made of simpler construction, and also to run slower; they are suitable for small launches and motor boats, in which they are connected directly to the propeller shaft without any intermediate gearing. Their mode of action may best be followed by commencing with the working stroke. The charge of gas is fired by a spark and the piston is driven forward; as it nears the end of the stroke it uncovers a port or opening in the side of the cylinder, which opens directly into the exhaust pipe, and the products of combustion commence to escape. The piston after advancing still further uncovers a second port, which communicates with a space containing the explosive gas, which has already been slightly compressed (*vide infra*), and therefore commences to flow into the cylinder. A projecting plate, or **Deflector**, on the piston deflects this stream of gas towards the top of the cylinder, thereby preventing it from escaping by the exhaust port, and further helping to sweep the burnt gas out of the cylinder. At the instant the working stroke ends, the cylinder is thus mainly filled by the fresh mixture; during the return stroke compression commences immediately the piston has passed the two open ports, and is completed at the end of the stroke, when ignition again occurs, and a fresh working stroke begins. As there is an explosion every revolution, the contact breaker can be

fixed on the main shaft, and no gear wheels and half speed shaft are required. The preliminary compression of the charge requires special arrangements; in some two stroke engines this is effected by a pump driven by the engine and communicating directly with the admission port. In another type the compression is produced in the crank chamber. During the up or return stroke of the piston the charge is drawn into the crank chamber through an admission valve which closes immediately the down or working stroke commences, and the piston itself compresses the charge; when the piston has passed the admission port the gas enters the latter through a tube or channel leading from the crank chamber. The only valve in this type of engine is the one by which the mixture enters the crank chamber, and that valve is of the simplest construction and automatic in action. If the purity of the mixture could be maintained and loss of unburnt gas through the exhaust port prevented, a two stroke engine should give approximately double the power (per stroke) of a four stroke engine of the same dimensions; but in practice these conditions are never fulfilled, and the power is little, if any, greater than that of a four stroke engine of the same size.

Petroleum Engines. *See* OIL ENGINES.

Petroleum, Mineral, *or* Rock Oil. An oily liquid found in the earth in many different parts of the world. From it are made several important and useful commodities, such as the well known illuminating oil, gasoline, naphtha, benzoline, and other oils which are more or less volatile; lubricating oils, vaseline, and paraffin wax. The supply of petroleum to England is almost wholly confined to the United States and Russia. A little crude oil is imported, and is refined in the neighbourhood of Chester, but nearly all of the petroleum products are received ready for use.

The origin of petroleum has been the subject of much speculation among scientific men, and various hypotheses have been advanced to account for it. The hypothesis which has obtained general acceptance is that petroleum is wholly derived from organic matter, often from a mixed animal and vegetable origin with a considerable preponderance of the former in the case of European petroleums and of the latter in that class of which Pennsylvania petroleum is a type. The oil as it comes from the earth varies in colour from a pale oil to a thick black substance, and in density from about 0·500 to 0·975. The chemical composition also varies largely, and is usually quite complex, comprising the series of hydrocarbons known respectively as the paraffin and the olefine series. In some examples nearly the whole series has been found to be present, while in others the olefines may be entirely missing. The quantity of carbon and hydrogen varies from 87·0 and 12·0 respectively, in the case of oil found in Java, to an average of 84·0 of carbon and 14·0 of hydrogen in Pennsylvanian oil. The method of obtaining the oil varies, but often consists of sinking wells which sometimes are 1,200 to 1,500 ft. deep. Usually the sides of the wells are lined, in order to prevent water percolating through, but this is not always necessary. In some cases, as soon as a well is sunk to a certain level, there is a great gush of oil, which may last for some days; but as a rule pumps are required to bring the oil to the surface. It is then conducted to storage tanks, and in a few cases put into barrels for conveyance to the refinery, but more often it is forced through pipe lines to central stations, where it is refined. These pipe lines are in some cases 6 in. in diameter, and as much as three hundred miles in length. A series of pumping engines are stationed along the line, about four being required in every hundred miles.

The refining of petroleum consists of a system of fractional distillation. The crude oil is introduced into a still of simple form connected with a condenser, an apparatus consisting of an elaborated coil upon which sprays of cold water descend. Fires being lighted under the still, the lighter vapours are first driven off, and are condensed in the coil or condenser. The first oil so obtained is crude naphtha, which is afterwards subjected to further distillation for the production of gasoline, benzene, and refined naphtha. The second product of the distillation of the crude petroleum is the source of the different burning oils. These are afterwards refined by agitating with sulphuric acid and caustic soda or ammonia solutions, the impurities uniting with the acid to form a tar, which is afterwards run off.

A third series of heavy oils are obtained from the still, and these are principally used for lubricating purposes after the wax has been withdrawn. The process of obtaining the different varieties of oil, although spoken of here as resulting in three separate classes, may be further divided up or arranged to produce directly a much greater number of oils according to the properties of the crude oil under treatment.

In the production of paraffin oils (*q.v.*) the process is essentially the same, excepting that the supply of crude oil, instead of being obtained from wells, is derived from bituminous shale by burning it in suitable retorts. In either case the distillation of the crude oil is proceeded with until there is nothing left but a little refuse in the shape of coke, and even this is of service for making fires on yachts and for domestic purposes, as it burns very brightly and gives off no smoke whatever. In some cases the coils used for condensing the vapours consist of a vertical network of coils of pipes through which the vapours pass, and are cooled in their progress simply by the action of the atmosphere. In others a shower or spray, produced by passing water from a tank through perforated plates so as to discharge over the coil, is used. Another form of condenser employed in the Scotch oil refineries consists of a long series of coils partly immersed in water. At various points upright water pipes are provided, at the end of which are pivoted crosspieces perforated with small holes. The holes on one arm of the crosspiece look the opposite way to those on the other, so that the force of the water causes these crosspieces to revolve, thus discharging the water upon the coils in the familiar manner of a revolving lawn sprinkler. The effect is to condense the vapours much quicker than by the atmosphere.

The heavier petroleum oils contain a considerable amount of paraffin wax, which is extracted by means of a refrigerating apparatus, in which brine is cooled by means of ammonia to about 10° F. below freezing point. The oil is first passed through D-shaped atmospheric coolers fitted with stirrers which assist the process by constantly presenting a fresh surface to the cold air. The oil is then brought into contact with the cold brine, when the wax solidifies. It is then passed through filter presses and subjected to a pressure of about two tons to the square inch. This squeezes out most of the oil, and leaves behind in the presses the crude wax, which in this condition is called "PARAFFIN SCALE." In Scotland considerable

quantities of this scale are refined, including that which is derived from the shale oil and that which is imported from America. The first process of refining the scale is to melt it in a tank heated by steam, and then to run it into shallow metal trays, where it is allowed to cool. The trays are then taken to the "sweating room," where the wax is placed on strips of hemp cloth, cocoanut matting, or other open fabric, supported in trays which are slightly inclined, and are fitted with channels so that the oil which is sweated out of the wax can run away. The heat varies from 80° to 100° F., and in from eight to twenty-four hours the process is complete. The melting point and absence of colour determine to a great extent the quality of paraffin wax, and the various grades are obtained by "sweating" at different temperatures. The oil which exudes from the wax is usually passed through a filter press, when it yields a further supply of scale, which in turn yields wax of a lower melting point. Paraffin wax is largely used by candle manufacturers, by taper makers, for making imitation parchment paper, and as an insulating agent in electrical work. Vaseline is another petroleum product, and is of great use in medicine. *See* VASELINE.

LIQUID FUEL, which is gradually coming into extensive use on steamships, locomotives, and stationary engines, consists of the residue of petroleum after the lighter and burning oils have been withdrawn by distillation. Most of the petroleum lubricating oils (*see* LUBRICANTS) are mixed with various other oils, animal or vegetable, or both. Thus an oil suitable for lubricating dynamos may be made by mixing cocoanut oil with mineral oil of specific gravity ·908 and ·885. PETROL employed in motors is a mixture of various light petroleum distillates, and should have a specific gravity of about ·7. Volatility and homogeneity of boiling points are, however, the most reliable tests of the quality of petrol.

Nearly every country has very stringent laws regulating the storage and sale of the lighter petroleum oils. In England oils giving off an inflammable vapour at over 73° F. when tested by the Abel close test apparatus are practically free from restrictions; but in most other countries the flashing point (*q.v.*) is higher, commonly 100° F. Various attempts have been made to amend the English law in this respect, but a section of the oil trade have thus far successfully opposed the proposal. The paraffin oil trade—a term generally used in connection with the Scotch shale oil industry—have always produced illuminating oils of high flashing point.—A. S. J.

Petrology *or* **Petralogy** (*Geol.*) The branch of geological science which is concerned with the study of rocks. Strictly speaking, the word denotes the study of the larger features of rocks as they occur in the field, without regard to their intimate structure as revealed in the laboratory by means of the microscopic examination of thin sections of the rocks under polarised light or by other means. This latter study, which has now attained to great importance, was originally, and should still be termed, Lithology.

Peu (*Music*). A little.

Phaleræ (*Archæol.*) Bosses or discs, generally of precious metal, worn by the Greeks and Romans upon helmets, and sometimes on breastplates. Phaleræ were also attached to the harness of horses, and were worn by Roman slaves.

Pharynx (*Zool.*) The cavity at the back of the mouth leading to the ŒSOPHAGUS, and also to the GLOTTIS or opening of the windpipe.

Phase (*Phys.*) If a particle be describing a Simple Harmonic Motion, and the displacement be defined by the equation $x = r \sin \theta$, then the angle θ (which is equal to ωt) is termed the PHASE. The angle θ may be measured from any fixed radius of the Circle of Reference. *See* SIMPLE HARMONIC MOTION.

Phaseolus (*Botany*). A genus of *Leguminosæ*, including the various species of beans.

Phase Rule (*Chem.*) (1) PHASE: Let some salt and water be placed in a stoppered bottle, and let there be more salt than the water can dissolve, and let the amount of salt and water be insufficient to fill the bottle. Then, the bottle being closed, we shall have present in it a homogeneous solid—the undissolved salt; a homogeneous liquid—the saturated solution of salt; and a homogeneous gas—vapour of water and some air. Each of these is called a phase. Suppose now sugar and ether are added to the contents of the bottle, the sugar being more in amount than can be dissolved by the water, and that the bottle is still not full. Then there are two solid phases—salt and sugar; two liquid phases—an aqueous solution of salt and sugar and a layer of ether; one gaseous phase containing air, water vapour, and ether vapour. Thus in any system every homogeneous solid in the system is a phase, so also is every homogeneous liquid, while there can only be one gas phase. (2) COMPONENTS: Every independently variable substance in a system is a component. Suppose the bottle to contain only salt, water, and water vapour, then there are two components. Again, imagine a sealed flask containing solid ammonium chloride and exhausted of air. Let it be heated to such a temperature that a part of the ammonium chloride vaporises and forms ammonia and hydrochloric acid gas. In this case there is only one component, viz. ($NH_3 + HCl$); for the ammonia cannot be present except there is an equivalent of the acid gas, and the composition of the gas phase is identical with that of the solid phase. But if ammonia gas were introduced into the system, then it would become a system of two components. (3) DEGREES OF FREEDOM: The *only* conditions which can effect a change of the equilibrium in a system according to the phase rule are temperature, pressure, concentration of components. The number of these remaining to be fixed before the state of the system considered becomes fixed and determinate is called the degrees of freedom of the system. Let P, C, and F denote respectively the number of phases, components, and degrees of freedom in any system which is *in equilibrium*, then the phase rule is

$$P + F = C + 2.$$

From this it is clear that in a system in equilibrium of one component there can never be more than two degrees of freedom nor more than three phases. Example: If ice, water, and water vapour exist together in equilibrium, the system has no degrees of freedom (invariant system), and any change of temperature, pressure, or concentration would mean that at least one phase must disappear. Suppose there are two components; then four phases can exist in equilibrium, but in this case the system is invariant: three phases could exist together with one degree of freedom (univariant system), etc. Example: Let the two components be sodium sulphate and water; then four phases which could exist together in equilibrium would be anhydrous sodium sulphate, Glauber's salt ($Na_2SO_4 10H_2O$), a solution of sodium sulphate of a particular concentra-

tion, water vapour at a definite and fixed pressure —say p.mm. Let the vapour pressure be reduced to p′.mm. and remain constant at this; then the system will change until a new equilibrium is set up, and the change will be very complex—the solution must become more concentrated, and this would involve the solid phases, one at least of which would disappear—while thermal changes also must occur. The state of a system is conveniently represented by diagrams. The above two component systems can be represented by two diagrams.

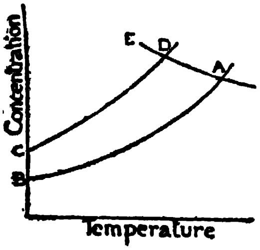


Diagram 1.

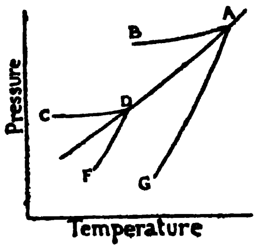


Diagram 2.

The first of these represents the solubilities of Na_2SO_4 (E D A), of $Na_2SO_47H_2O$ (C D), of $Na_2SO_410H_2O$ (A B). The second represents the vapour pressures of the solution of Na_2SO_4 (A D), of the solution of $Na_2SO_410H_2O$ (A B), of the solid $Na_2SO_410H_2O$ (A G), of the solution of $Na_2SO_47H_2O$ (C D), of the solid $Na_2SO_47H_2O$ (D F). The equilibrium of the four phases referred to above is indicated by the point A (quadruple point) in the two diagrams. It is clear there is another quadruple point D, where the four phases—solid Na_2SO_4, solid $Na_2SO_47H_2O$, solid of Na_2SO_4 of a particular concentration, water vapour at a particular pressure denoted by the point D in Diagram II.—can exist in equilibrium. The phase rule is of great service in studying the various hydrates of salts and the formation of salt deposits, such as those at Stassfurt, and in studying alloys such as the copper tin alloys and the carbon iron alloys. It will be noticed that the phase rule does not distinguish between physical and chemical changes, and that it takes no account of the mass of any phase; but the mass must not be so small that surface tension effects interfere with the changes.

Phases of the Moon (*Astron.*) Apparent changes in form of the illuminated portion of the moon turned towards the Earth, due to the moon's motion round the Earth.

Phase Splitter (*Elect. Eng.*) A device for producing a difference of phase between two alternating currents which were originally in the same phase, or which were derived from a single alternating current. A phase splitting device is often used in starting a single phase alternating current motor.

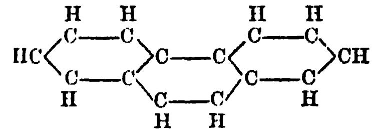
Phellogen (*Botany*). *See* CAMBIUM.

Phenacetin (*Chem.*) Paracetamidophenetole, $CH_3CONHC_6H_4OC_2H_5$. A white crystalline (scales) solid; melts at 135°; very sparingly soluble in water; soluble in alcohol and glycerine. It is used in medicine to relieve pain. Strong sulphuric acid converts it into ethyl acetate and paramidophenol,

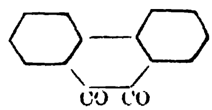
$$CH_3CONHC_6H_4OC_2H_5 + H_2O = CH_3COOC_2H_5 + H_2N \cdot C_6H_4OH.$$

It is prepared from paranitrophenol; the potassium salt of the latter, on boiling with alcohol and potassium ethyl sulphate, gives paranitrophenetole, which on reduction gives paramidophenetole; and this compound when boiled with glacial acetic acid gives phenacetin.

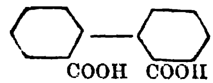
Phenanthrene.



A white crystalline solid (plates); melts at 99°; slightly soluble in water; easily soluble in ether, benzene, and hot alcohol; its solutions have faint blue fluorescence. Forms a picrate which melts at 140°. Forms substitution products with chlorine, nitro-derivatives with nitric acid, and sulphonic acids with sulphuric acid. On oxidation with chromic acid it gives phenanthraquinone,



a yellow crystalline (needles) solid, which melts at 198°. This compound on further oxidation gives diphenic acid,



and diphenic acid when heated with soda-lime gives diphenyl, $C_6H_5 - C_6H_5$. These reactions show that phenanthrene is a diphenyl derivative, and as phenanthrene can be obtained by passing dibenzyl or stilbene through a red-hot tube, its constitution must be represented as above.

$$\begin{array}{c} C_6H_5 \cdot CH_2 \\ | \\ C_6H_5 \cdot CH_2 \end{array} \rightarrow \begin{array}{c} C_6H_4 \cdot CH \\ | \quad\quad \| \\ C_6H_4 \cdot CH \end{array} \leftarrow \begin{array}{c} C_6H_5 \cdot CH \\ \| \\ C_6H_5 \cdot CH \end{array}$$

It occurs in crude anthracene, from which it can be separated by carbon disulphide—in which it is more soluble than anthracene—and purified by conversion into the picrate. Morphine is a phenanthrene derivative.

Phenetole (*Chem.*) $C_6H_5OC_2H_5$. The ethyl ether of phenol. It is a colourless oil which boils at 172°. It may be obtained by the action of ethyl iodide on potassium phenate.

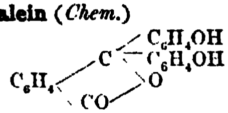
Phenol (*Chem.*) C_6H_5OH, Carbolic acid. Forms colourless prisms; melts at 42°; boils at 183°; is volatile in steam; has a characteristic smell; blisters the skin; is very poisonous; largely used as a disinfectant. Soluble in water (1 part in 14 parts water); more soluble in the usual organic solvents, alcohol, ether, benzene, etc. It is deliquescent. When exposed to air and light it turns red. Chlorine and bromine yield symmetrical trichlor- and tribrom-phenol, $C_6H_2Br_3OH$; in presence of a halogen carrier chlorine will yield higher chlorinated products, while in alkaline solution it breaks the benzene ring. Sulphuric acid probably forms phenyl sulphuric acid, $SO_2\langle^{OC_6H_5}_{OH}$; but this undergoes rearrangement to ortho- and para-phenol sulphonic

acids, $HOC_6H_4SO_2OH$. Salts of phenyl sulphuric acid are known, and potassium phenyl sulphate, $SO_2\langle^{OC_6H_5}_{OK}$, occurs in urine. Nitric acid gives a mixture of ortho- and para-nitrophenol; stronger acid gives picric acid (*q.v.*) The phenyl group confers slight acid properties on the hydroxyl hydrogen atom, so that phenol unites with powerful bases to form salts: *e.g.* with caustic soda and caustic potash it forms sodium and potassium phenates, C_6H_5ONa and C_6H_5OK; but it will not react with a carbonate. Like an alcohol, phenol forms ethers with other alcohols; *e.g.* potassium phenate and methyl iodide give phenylmethyl ether (anisole), $C_6H_5OCH_3$ (*see also* PHENETOLE); with acids (better, acid-chlorides) it forms esters, *e.g.*:

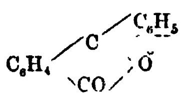
$$C_6H_5OH + ClOC.CH_3 = \underset{\text{Phenyl Acetate.}}{CH_3COOC_6H_5} + HCl$$

Ferric chloride imparts a violet colour to its solution. Concentrated sulphuric acid, followed by a solution of a nitrite, gives a deep red colour with phenol, which turns blue with alkali (Liebermann's Reaction). For other reactions relating to phenol, *see* SALICYLIC ACID, PICRIC ACID, NITRO COMPOUNDS, NITROSO COMPOUNDS. The chief source of phenol is coal tar. *See* GAS MANUFACTURE, p. 248. It can be obtained from benzene-sulphonic acid by fusion with caustic potash; also by boiling diazobenzene sulphate (*see* DIAZO REACTIONS) with water.

Phenolphthalein (*Chem.*)



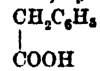
Small yellowish white crystals; melts at 250°; insoluble in water; soluble in alcohol. It is prepared by heating together 5 parts phthalic anhydride, 10 parts phenol, and 4 parts concentrated sulphuric acid for several hours at 115 to 120°. The product is extracted by boiling with water, the insoluble part dissolved in caustic soda solution, and the phenolphthalein precipitated from this solution by neutralisation with acetic acid and a little hydrochloric acid. That it has the above constitution is shown by its preparation from phthalophenone,



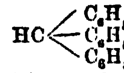
by successive nitration, reduction, and diazotisation. *See* PHTHALEINS. Phenolphthalein is a valuable indicator (*q.v.*); it is specially useful in the titration of weak acids by strong alkalis; it should not be used with weak bases. Excess of a strong alkali decolorises it. For its use as an indicator and the theory of its action, *see* INDICATORS.

Phenols (*Chem.*) A class of compounds derived from benzene or from homologues of benzene by replacing one or more hydrogen atoms of the benzene nucleus by hydroxyl groups. For examples *see* PHENOL, PICRIC ACID, THYMOL, CRESOLS, CATECHOL, HYDROQUINONE, RESORCIN, PYROGALLOL, PHLOROGLUCIN.

Phenyl (*Chem.*) The name given to the group C_6H_5, derived from benzene by removal of any one atom of hydrogen. The group has no independent existence. The word is much used in naming benzene derivatives, *e.g.*



Phenylacetic Acid.

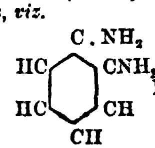


Triphenylmethane.

Phenylene (*Chem.*) A name given to the group C_6H_4, which is derived from benzene by the removal of any two of its hydrogen atoms. When the two hydrogen atoms removed are adjacent, the residue is called orthophenylene; when next but one to each other, metaphenylene; when opposite, paraphenylene. The group has no independent existence.

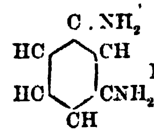
Phenylenediamines (*Chem.*) There are three of these compounds, *viz.*

Orthophenylene-diamine



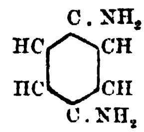
M.P. 102°. B.P. 252°.

Metaphenylene-diamine



M.P. 63°. B.P. 287°

Paraphenylene-diamine

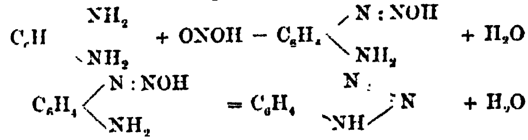


M.P. 147° B.P. 267°.

They are all white crystalline (plates) solids; soluble in water; more soluble in alcohol and ether. They are diacid bases. *The ortho-compound* Benzanilide is nitrated, the product saponified and distilled in steam, when orthonitraniline distils over; this is reduced by caustic soda and zinc dust.

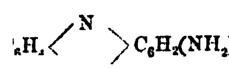
$$C_6H_5NHCOC_6H_5 \rightarrow C_6H_4NO_2NHCOC_6H_5 \rightarrow C_6H_4NO_2NH_2 \rightarrow C_6H_4(NH_2)_2$$

The orthonitraniline can also be prepared by heating orthonitrophenol with ammonia under pressure. With nitrous acid it gives azimidobenzene:



Azimidobenzene.

On oxidation it gives unsymmetrical diaminophen-



The meta-compound is obtained by reduction of metadinitrobenzene with tin and hydrochloric acid. *See* NITROBENZENE. With nitrous acid it yields Bismarck Brown (*q.v.*) *The para-compound* is obtained by nitrating acetanilide in presence of much sulphuric acid at a low temperature; the paranitracetanilide is hydrolysed, and the resulting paranitraniline reduced by tin and hydrochloric acid. It is also obtained by heating phenylhydrazine with hydrochloric acid at 200°. For its reaction with ferric chloride and sulphuretted hydrogen *see* LAUTH'S VIOLET. It is

oxidised by manganese dioxide and sulphuric acid to quinone. A hypochlorite gives quinone dichlorimide, $ClN:C_6H_4:NCl$. Its dimethyl derivative (paradimethylphenylenediamine) is used in the preparation of methylene blue (*q.v.*), and is prepared by reducing nitrosodimethyl aniline. *See* NITROSO COMPOUNDS, INDAMINES, SAFFRANINE.

Phenylhydrazine (*Chem.*) $\genfrac{}{}{0pt}{}{C_6H_5}{H}{>}N.NH_2$

Colourless prisms or plates; melts at 23°; boils at 246°, with decomposition; peculiar smell; sparingly soluble in water; easily soluble in alcohol, ether, etc. It is a base, forming well crystallised salts, *e.g.* phenylhydrazine hydrochloride, $C_6H_5NH:NH_2HCl$. It reduces Fehling's solution. Zinc dust and hydrochloric acid reduce it to aniline and ammonia. Boiled with copper sulphate or ferric chloride, it yields benzene. With aldehydes and ketones it yields hydrazones (*q.v.*) With sugar it yields osazones (*q.v.*) For its reaction with acetoacetic ester, *see under* ETHYLACETOACETATE. It is very important as a reagent for aldehydes, ketones, and sugars; also in the preparation of antipyrine (*q.v.*) It is prepared by diazotising aniline with hydrochloric acid and sodium nitrite (*see* DIAZO REACTIONS), and reducing the diazobenzene chloride with tin and hydrochloric acid; this gives phenylhydrazine hydrochloride, which is filtered off, dissolved in water, decomposed by potash, and extracted with ether. The ether is distilled off, and the base fractionally distilled under reduced pressure.

Phenylisocyanate (*Chem.*) $C_6H_5N:CO$, Carbanil. A colourless liquid; boils at 166°; penetrating smell. It reacts with compounds containing hydroxyl and amino groups to form substituted ureas, *e.g.*

$$2C_6H_5N:CO + HOH = (C_6H_5.H.N)_2CO + CO_2$$

$$C_6H_5N:CO + NH_3 = \begin{matrix} C_6H_5.HN \diagdown \\ \quad CO. \\ H_2N \diagup \end{matrix}$$

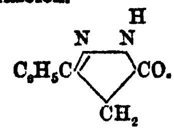
Hence it is used in determining the presence of these groups in compounds, and also sometimes in isolating such compounds from mixtures. It is prepared by acting on diazobenzene chloride (*see* DIAZO REACTIONS) with potassium cyanate and finely divided copper; also by heating phenyl mustard oil (*see* MUSTARD OILS) with mercuric oxide.

Phenylisocyanide (*Chem.*) C_6H_5NC, Phenylcarbylamine. A colourless liquid; boils at 166° and polymerises; boils unchanged under reduced pressure; powerful and offensive smell, which causes sickness; on keeping it turns blue in colour and resinises. On heating at 220° it undergoes rearrangement to phenyl cyanide, C_6H_5CN; on reduction it yields methyl aniline. It is obtained by heating aniline with chloroform and alcoholic potash.

$$C_6H_5N\begin{matrix}\diagup H \\ \\ \diagdown H\end{matrix} + \begin{matrix}Cl\diagdown \\ \\ Cl\diagup\end{matrix}C\begin{matrix}\diagup Cl \\ \\ \diagdown H\end{matrix} + 3KOH = C_6H_5NC + 3KCl + 3H_2O.$$

This reaction is used as a test for chloroform or aniline, as the smell of the isocyanide is unmistakable.

Phenylpropiolic Acid (*Chem.*) $C_6H_5C:C.COOH$. A white crystalline solid; melts at 136°; heated to 120° with water it gives phenylacetylene, $C_6H_5C:CH$, and carbon dioxide; on reduction with sodium and alcohol it gives cinnamic acid; with hydrazines it forms pyrazole derivatives, *e.g.* hydrazine hydrate gives 3-phenylpyrazolon.



It is obtained from dibromcinnamic acid (*see* CINNAMIC ACID) by boiling with alcoholic potash. The ortho-nitro phenylpropiolic acid is similarly obtained from orthonitrocinnamic acid dibromide; alkaline reducing agents, *e.g.* grape sugar and caustic potash, convert it into indigo.

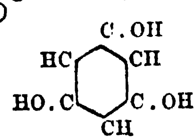
Pheon (*Her.*) The barbed iron head of spear or arrow, engrailed on the inner side, generally with point downwards.

Phigaleian Marbles (*Sculp.*) The name given to the sculptured frieze of the cella of the Temple of Apollo at Phigalia, in Arcadia. It was brought to this country early in the nineteenth century, and is now in the British Museum. Represents contests between the Centaurs and Lapithæ. *See* ELGIN MARBLES.

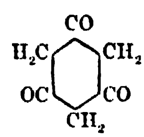
Phlexine. *See* DYES AND DYEING.

Phloridzin (*Chem.*), $C_{21}H_{24}O_{10}$. White crystalline solid (needles); melts at 108°; sparingly soluble in cold water, easily soluble in hot water and in alcohol. Lævorotatory. Hydrolysed by acids to glucose and phloretin. The latter is the phloroglucinol ester of paraoxyphenylpropionic acid. $HOC_6H_4CH_2.CH_2.COOH$. When phloridzin is administered it gives rise to a condition known as phloridzin diabetes. In this condition far more glucose is excreted in the urine than can be accounted for by the hydrolysis of the phloridzin: and phloretin itself, which contains no glucose residue, can produce phloridzin diabetes. It is supposed therefore that the glucose arises from protoplasmic metabolism. Phloridzin occurs in the root bark of a number of common fruit trees, such as the apple, cherry, pear, and plum; it can be extracted from these barks by dilute alcohol.

Phloroglucinol (*Chem.*) (1 : 3 : 5-trihydroxybenzene)



tautomeric form :—



(1 : 3 : 5-triketohexamethylene).

Crystallises in colourless prisms with two molecules of water; loses its water at 100° and melts at 218°; soluble in water, alcohol, and ether; sweet taste. Its aqueous solution is coloured violet by ferric chloride, and is resolved by passing in chlorine into dichloracetic acid and tetrachloracetone. Its alkaline solution absorbs oxygen and reduces Fehling's solution. Phloroglucinol yields a triacetate with acetyl chloride. With hydroxylamine it reacts in the tautomeric form and yields a trioxime. In the form of Gunsberg's reagent it is used as a test for free hydrochloric acid in the gastric juice. When the reagent (2 parts phloroglucinol, 1 part vanillin, 30 parts

rectified spirit) is warmed with the liquid to be tested, it gives a red colour—sensitive to 1 part acid in 10,000. It is also used, mixed with hydrochloric acid, as a test for pentoses, with which it gives a red colour with a characteristic absorption band. It is formed when quercetin, gamboge, dragon's blood, and other resins are fused with caustic potash. To prepare it, resorcin (*q.v.*) is fused with caustic soda, or symmetrical trinitrobenzene is reduced by tin and hydrochloric acid, and the resulting double salt of triamidobenzene and tin hydrochlorides hydrolysed by caustic soda. It is also obtained by fusing ethylphloroglucin tricarboxylate with caustic potash. *See* MALONIC ACID.

Phobos (*Astron.*) The inner satellite of Mars.

Phone. A colloquial contraction for Telephone.

Phonograph. A machine for recording and reproducing definite sounds. To produce a RECORD, the voice or sound to be recorded is made to set in vibration a light diaphragm, carrying a sharp tracing point or style, which makes contact with a cylinder coated with wax. This cylinder is caused to revolve, and the recorder to slowly travel from one end of the cylinder to the other. As it does so the movement of the style cuts a groove, whose depth corresponds to the vibrations of the diaphragm. If the sharp point be replaced by a smooth ended needle, which is allowed to rest in the groove, the motion of the cylinder will cause the style, and therefore the diaphragm, to reproduce its original vibrations, and thereby reproduce the sounds which caused these vibrations with more or less fidelity. The instrument is frequently sold under the name GRAPHOPHONE, and large numbers of records of all kinds can be obtained. In the GRAMAPHONE the records are formed on a flat rotating disc, but the essential principle remains unaltered except that records cannot be made by the user.

Phonolite (*Geol.*) In its original sense it meant any rock of eruptive origin which clinked or gave forth a kind of metallic ring when struck with a hammer. At the present day the term is restricted to an eruptive rock (generally, if not always, of trappean mode of occurrence, *i.e.* intrusive), which consists of a lithoidal ground mass agreeing in mineral constitution with Syenites and Trachytes (*q.v.*), but which contains the mineral Nepheline.

Phormium (*Botany*). The generic name for New Zealand flax.

Phorone (*Chem.*)

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>\!C:CH-CO\cdot\cdot CH:C\!<\!\begin{matrix}CH_3\\CH_3\end{matrix}$$

Yellow prisms (it contains the group $-\underset{\|}{C}-\overset{O}{\overset{\|}{C}}-\underset{\|}{C}-$ like quinone); melts at 28°; boils at 197°; smells like geranium; soluble in alcohol and benzene. Boiled with dilute sulphuric acid it yields mesityl oxide and acetone; heated with strong sulphuric acid, mesitylene. Like a ketone, it unites with sodium hydrogen sulphite, forms an oxime, and unites with hydrocyanic acid (KCN solution and HCl). It is obtained, along with mesityl oxide (*q.v.*), by the action of hydrochloric acid on acetone, and is separated by fractional distillation from the mesityl oxide, which only boils at 132°.

Phosgene Gas (*Chem.*) An old name for CARBONYL CHLORIDE (*q.v.*)

Phosgenite (*Min.*) A chloride and carbonate of lead, $PbCl_2 . PbCO_3$. White or grey, sectile; from Cromford in Derbyshire, Elgin, Cornwall, etc. *Also called* CROMFORDITE.

Phosphate of Iron (*Min.*) *See* VIVIANITE.

Phosphate of Lead (*Min.*) *See* PYROMORPHITE.

Phosphate of Lime (*Min.*) *See* APATITE.

Phosphates (*Chem.*) Salts of orthophosphoric acid, H_3PO_4. *See* under PHOSPHORUS COMPOUNDS. The individual phosphates, when they are of importance, are described under the corresponding metal. *See* SODIUM COMPOUNDS, CALCIUM COMPOUNDS, MAGNESIUM COMPOUNDS.

Phosphatic Nodules (*Geol.*) These are often, but erroneously, spoken of under the name of COPROLITE. They consist essentially of calcareous matter, containing a sufficiently high percentage of phosphoric acid to be of commercial value in the manufacture of artificial manures. The phosphoric acid seems to be, in nearly all cases, of organic origin; but the precise mode of formation of the nodules is not yet well understood. Important deposits of phosphate of lime arise from the prolonged action of guano upon limestone islands in the rainless regions of the Pacific. Others may be due to the decomposition on the ocean floor of large numbers of fish which have been killed by a sudden change of temperature of the sea water in which they lived.

Phosphides (*Chem.*) Compounds formed by the union of phosphorus and one other element, *e.g.* calcium phosphide. *See* CALCIUM COMPOUNDS *and* HOLMES'S SIGNAL.

Phosphine (*Chem.*) A name for phosphoretted hydrogen. *See under* PHOSPHORUS COMPOUNDS.

Phosphines (*Chem.*) Compounds derived from phosphine (phosphoretted hydrogen) by replacing the hydrogen by alcohol radicals, *e.g.* $P(C_2H_5)_3$ is triethyl phosphine, $PH_2C_2H_5$ is ethyl phosphine.

Phosphomolybdic Acid (*Chem.*) *See* MOLYBDENUM AND ITS COMPOUNDS.

Phosphonium Compounds (*Chem.*) The name phosphonium is given to the group PH_4, from analogy with the group NH_4, which is called ammonium. PHOSPHONIUM CHLORIDE, PH_4Cl, does not exist under the ordinary conditions of temperature and pressure. It is formed by the union of phosphoretted hydrogen and hydrogen chloride either at −25° or under a pressure of 20 atmospheres at the ordinary temperature. PHOSPHONIUM BROMIDE, PH_4Br, is a white crystalline solid which dissociates into phosphoretted hydrogen and hydrogen bromide at its melting point, *viz.* 30°; it is decomposed by water into the same substances, and it is formed from them by direct union at the ordinary temperature. PHOSPHONIUM IODIDE, PH_4I, is a shining crystalline solid; easily sublimes on warming; boils at 80°, and dissociates into phosphoretted hydrogen and hydriodic acid; decomposed by water into the same substances; warmed with caustic potash it gives phosphoretted hydrogen. *See* PHOSPHORUS COMPOUNDS. It is formed by dissolving phosphorus and iodine in carbon disulphide in a retort, evaporating the solvent in a stream of carbon dioxide, and gently heating the residue, with gradual addition of water. The phosphonium iodide sublimes. The carbon dioxide is to exclude air, and materials and apparatus must be dry. Phosphonium iodide is used in

the preparation of organic derivatives of phosphorus, such as triethylphosphine $P(C_2H_5)_3$. *See* PHOSPHORUS COMPOUNDS.

Phosphor Bronze (*Met.*) Bronze containing 2 to 5 per cent. of phosphorus. It is very hard and durable, and suitable for parts of machinery exposed to shocks. As its electrical conductivity is good, it is employed for telephone wires, etc., being much stronger than pure copper.

Phosphorescence (*Phys.*) Certain substances, after exposure to light, exhibit a degree of luminosity for some time. This property is termed PHOSPHORESCENCE. The sulphides of calcium, barium, and strontium are examples.

Phosphoretted Hydrogen (*Chem.*) *See* PHOSPHORUS COMPOUNDS.

Phosphorus (*Chem.*) P. Atomic weight, 31. A colourless crystalline solid; but ordinarily it is slightly yellow and translucent; melts at 44°, and sublimes below this temperature in an atmosphere which does not act on it; boils at 290°; it has a vapour density corresponding to the formula P_4 at 1,000°, and to the formula P_2 at 1,750°. Phosphorus is insoluble in water, slightly soluble in ether and a number of oils, easily soluble in carbon disulphide. It is very poisonous, and on this account is used as a vermin killer. The "phosphorus paste" used for this purpose consists of fat mixed with a little phosphorus, and usually flour and sugar and a colour. Its vapour also is dangerous, as it attacks and destroys the jawbones of people such as matchmakers, who are constantly exposed to its action. Phosphorus unites directly with many elements. With oxygen it unites with extreme ease in presence of moisture, but not at all in the total absence of moisture. The luminosity of phosphorus seen in the dark or in a feeble light is due to a low temperature flame arising from the slow combustion of the phosphorus in moist air or oxygen; in oxygen at atmospheric pressure phosphorus is not luminous, but becomes so on reducing the pressure or on warming. The glow of phosphorus is prevented by the presence of small quantities of easily oxidisable gases and vapours. A piece of phosphorus left exposed to air will take fire spontaneously on standing; on warming, it ignites at 60°, forming chiefly the pentoxide; on this account phosphorus is kept under water. The products of this slow oxidation are phosphorous oxide, phosphoric oxide, ozone, and hydrogen peroxide; the two oxides unite with water, and give phosphorous and phosphoric acids. Phosphorus readily unites with all the halogens; iodine put upon phosphorus sets it on fire in air; phosphorus dropped into bromine instantly unites with it with a loud explosion, and it burns spontaneously in chlorine and fluorine. Placed in solutions of salts of metals with easily reducible oxides, phosphorus precipitates the metal, which in some cases unites with the phosphorus to form a phosphide, *e.g.* it precipitates silver from silver nitrate—Stas prepared pure silver in this way; it precipitates copper from copper sulphate, and the copper unites with the phosphorus to form a phosphide. For the action of alkalis and nitric acid, *see* PHOSPHORUS COMPOUNDS. Ordinary phosphorus under the influence of heat and certain catalytic agents (a trace of iodine or phosphorus tribromide) changes to the red modification. This red phosphorus consists of very small crystals, and is insoluble in those solvents which dissolve ordinary phosphorus, is not poisonous, takes fire at a much higher temperature in air, and in general reacts slowly with those elements and compounds which react rapidly with ordinary phosphorus, and has a much lower vapour pressure and higher melting point than ordinary phosphorus. As yellow phosphorus changes with extreme slowness at the ordinary temperature into the red modification, it is probable that the red form is a polymer of the ordinary form. To obtain the red form in quantity, ordinary phosphorus is heated out of air at 250° or over; at 300° the change is very rapid. Over 350°, when the vapour pressure of the red form becomes very appreciable, this form is reconverted into the yellow form. Red phosphorus is soluble in a solution of caustic potash in diluted alcohol, and hydrochloric acid reprecipitates it from this solution. Yellow phosphorus is used in tipping ordinary matches; red phosphorus is used on the rubber and not on the tip of the match in making safety matches. Phosphorus occurs naturally as phosphates. *See under* APATITE; CALCIUM COMPOUNDS; PHOSPHORITE; WAVELLITE. It also occurs in bone (*see* BONE ASH) and in nerve tissue (*see* LECITHINS). Phosphorus is obtained by heating an intimate mixture of calcium phosphate, carbon, and sand in an electric furnace with carbon electrodes, and condensing the phosphorus vapour under water in copper vessels; the yield is about 86 per cent. It can be obtained in the laboratory by heating a mixture of aluminium powder (2·5 equivs.), sodium metaphosphate (6 equivs.), and silica (2 equivs.) in a porcelain boat contained in a piece of combustion tubing, in a stream of dry hydrogen. The phosphorus is condensed in a receiver attached to the combustion tube:

$$6NaPo_3 + 10Al + 3SiO_2 = 3NaSi_2O_3 + 2Al_2O_3 + 6P.$$

Phosphorus Compounds. WITH HYDROGEN: *Phosphoretted hydrogen* or *phosphine*, PH_3; a colourless gas; melts at −134°; boils at −85°; characteristic smell (variously described as like that of putrid fish or like garlic); very poisonous; slightly soluble in water; takes fire in air on slight heating or in oxygen on sudden reduction of pressure, and forms metaphosphoric acid and water, $4PH_3 + 16O = P_4O_{10} + 6H_2O = 2H_2P_2O_6 + 4H_2O$; decomposed to phosphorus and hydrogen on heating. It has feebly basic properties, and unites directly with hydriodic acid and hydrobromic acid at the ordinary temperature and pressure, but only at −25° with hydrochloric acid. When passed into solutions of salts of many metals, the metal or a phosphide is precipitated. It is obtained by heating phosphorus with a strong solution of an alkali—

$$P_4 + 3KOH + 3H_2O = \underset{\text{Pot. Hypophosphite.}}{3KH_2PO_2} + PH_3$$

In this case the gas is mixed with hydrogen, and another hydride, P_2H_4, which makes it spontaneously inflammable. A similar impure product arises from the action of calcium phosphide on water. The pure gas is obtained by the action of a solution of caustic potash on phosphonium iodide; the gas is only pure when the action is slow. OTHER HYDRIDES: A liquid hydrogen phosphide, P_2H_4, is obtained along with the gaseous hydride PH_3, when the latter is prepared by the action of caustic potash on phosphorus or water on calcium phosphide. It is separated from the gas by passing the gas through a tube cooled to 0°. It is a colourless liquid, which boils at 57° (735 mm.); immediately catches fire in air; decomposed by light, by heating above its boiling point, and by hydrochloric acid into a *solid* hydride and phosphoretted hydrogen, $5P_2H_4 = 2P_2H + 6PH_3$. The solid hydride is yellow, catches fire in air on heating,

and is decomposed into phosphorus and hydrogen on heating out of air. WITH HALOGENS: Phosphorus unites with all the halogens directly. The trifluoride PF_3 and pentafluoride PF_5 are gases. The *trichloride* PCl_3 is a colourless liquid; boils at 76°; fumes in air owing to its decomposition by water vapour. Water decomposes it, forming phosphorous and hydrochloric acids, $PCl_3 + 3HOH = 3HCl + H_3PO_3$. It behaves in a similar manner with organic compounds which contain hydroxy groups; for this reason it is an important reagent in organic chemistry, *e.g.* $3CH_3CO.OH + PCl_3 = 3CH_3COCl + H_3PO_3$. It is obtained by passing dry chlorine over phosphorus; the product contains pentachloride, which is removed by standing for a while over phosphorus and then distilling. The *pentachloride* PCl_5 is a yellowish white solid with powerful smell; sublimes without melting at the ordinary pressure; fumes strongly in air, owing to decomposition by water vapour. On heating it dissociates, so that its vapour is a mixture of chlorine and trichloride. When water acts slowly on it, phosphorus oxychloride is formed, $PCl_5 + H_2O = POCl_3 + 2HCl$; but the oxychloride itself is easily decomposed by water, so that with much water phosphoric acid is formed, $POCl_3 + 3HOH = PO(OH)_3 + 3HCl$. With organic or inorganic compounds containing hydroxy groups it reacts in a similar way; with organic compounds containing the carbonyl group($-CO-$) the oxygen is replaced by two chlorine atoms—hence it is an important reagent for the detection of these groups. Examples:

$$SO_2\langle{}^{OH}_{OH} + PCl_5 = \underset{\text{Chlorsulphonic Acid.}}{SO_2\langle{}^{OH}_{Cl}} + POCl_3 + HCl$$

$$\underset{\text{Acetone.}}{(CH_3)_2CO} + PCl_5 = (CH_3)_2CCl_2 + POCl_3$$

It is formed by the action of chlorine on the trichloride. The *tribromide* PBr_3 resembles the trichloride, and is prepared by mixing carbon disulphide solutions of phosphorus and bromine and distilling off the solvent. The *pentabromide* PBr_5 is a yellow crystalline solid obtained by direct union of bromine with the tribromide. A *heptabromide*, PBr_7, a red crystalline solid, decomposed into bromine, phosphoric and hydrobromic acids by water, is formed by mixing the pentabromide and bromine, and heating in a sealed tube at 90°, when the heptabromide sublimes. A *di-iodide*, P_2I_4, and tri-iodide are known; but the existence of a penta-iodide is doubtful. Many *oxyhalogen compounds* are known. The *oxyfluoride* POF_3 is formed by direct union of the trifluoride and oxygen; it is a gas. The *oxychloride* $POCl_3$ is a liquid; melts at $-1.5°$; boils at 107°. It fumes in air, owing to the presence of water vapour. Water decomposes it. *See* above. It is prepared by the action of anhydrous oxalic acid on the pentachloride,

$$\begin{matrix}COOH\\ |\\ COOH\end{matrix} + PCl_5 = CO + CO_2 + 2HCl + POCl_3;$$

also by heating the pentachloride and pentoxide in a sealed tube; by the action of potassium chlorate on the trichloride; by the action of ozone on the trichloride. It is used, like the trichloride, in organic chemistry. WITH SULPHUR: The *pentasulphide* P_2S_5 a pale yellow crystalline solid; melts at 275°; boils at 518°; decomposed by water, $P_2S_5 + 8H_2O = 2H_3PO_4 + 5SH_2$. It is used in organic chemistry in the preparation of sulphur compounds. *See* DIKETONES; LÆVULINIC ACID; MERCAPTANS. It may be prepared by heating red phosphorus and sulphur together in the proper proportions and distilling the product in a stream of carbon disulphide. WITH OXYGEN AND OXYGEN AND HYDROGEN—OXIDES AND ACIDS: *Phosphorous oxide*, P_4O_6, is a white crystalline solid; melts at 22·5°; boils at 173°; its vapour density corresponds to the formula P_4O_6; soluble in ether, carbon disulphide, benzene, and chloroform; burns in air and with great brilliancy in warm oxygen to phosphoric oxide; with cold water it slowly forms phosphorous acid, and with dilute alkalis phosphites. With warm water the action is energetic, and red phosphorus, spontaneously inflammable phosphoretted hydrogen, and phosphoric acid are produced. It is formed when phosphorus burns in a restricted supply of air. *Phosphorosophosphoric oxide*, $P_4O_6.P_4O_{10}$, is a colourless, shining, crystalline solid; dissolves slowly in water with hissing sound, and forms a mixture of phosphorous and metaphosphoric acids; on heating, it sublimes without melting and without decomposition. It is obtained by heating phosphorous oxide in an exhausted tube, when phosphorus distils away first and is followed by the phosphorosophosphoric oxide. Its vapour density at 1,400° is 229. *Phosphoric oxide*, P_4O_{10}, is ordinarily a soft white powder, but can be obtained in crystals by sublimation; on heating, it sublimes without melting; its vapour density at 1000° corresponds to a formula not less than P_4O_{10}; it combines with water with great energy, forming metaphosphoric acid, $P_4O_{10} + 2H_2O = 2H_2P_2O_6$. On this account it is used as a drying and dehydrating agent; thus, when added to nitric acid it withdraws water, and nitrogen pentoxide is formed. To obtain it, phosphorus is burnt in a free supply of air or oxygen previously dried by sulphuric acid; the product contains some phosphorous oxide, which may be removed by vapourising it in a current of oxygen and passing the mixed gases over heated spongy platinum. *Hypophosphorous acid*, H_3PO_2. *See* HYPOPHOSPHOROUS ACID. *Phosphorous acid*, H_3PO_3, is a crystalline solid; melts at 74°; it is very deliquescent. When heated it gives phosphoretted hydrogen and phosphoric acid, $4H_3PO_3 = 3H_3PO_4 + PH_3$. It is a powerful reducing agent; its solution absorbs oxygen from the air, and reduces salts of gold, silver, mercury, and copper to the metallic state. With phosphorus pentachloride it gives phosphorus trichloride, $H_3PO_3 + PCl_5 = PCl_3 + 3POCl_3 + 3HCl$. It is a tribasic acid, but the third hydrogen atom is difficultly replaced by metals. Its salts, the phosphites, are not important. The acid is obtained by the action of cold water on phosphorous oxide; by the action of the trichloride on water; or by heating the trichloride with crystallised oxalic acid. *Phosphorosophosphoric acid* (Hypophosphoric acid), $H_4P_2O_6$, is a white crystalline solid; melts at 55°; decomposes on heating into phosphoric acid and phosphoretted hydrogen; it is a weak reducing agent; it is tetrabasic. The acid is formed, along with phosphorous and phosphoric acids, when phosphorus is exposed to the action of moist air. When the liquid which results from this prolonged exposure is partly neutralised by caustic soda, the sparingly soluble sodium salt, $Na_2H_2P_2O_6$, crystallises out. A solution of this salt is decomposed by lead acetate, and the precipitated lead salt decomposed by sulphuretted hydrogen. The solution is concentrated in a vacuum. PHOSPHORIC ACIDS: *Orthophosphoric acid*, $H_3PO_4 = PO(OH)_3$: a white crystalline solid; melts at 42°; it is difficult to crystallise, and is usually met with as a thick syrupy liquid. It is extremely soluble in water. On heating to 213° it

forms *Pyrophosphoric acid*, $H_4P_2O_7$, $2H_3PO_4 = H_2O + H_4P_2O_7$. Orthophosphoric acid is tribasic. It is obtained by the action of phosphorus pentachloride (*q.v.*) on water; usually by boiling red phosphorus with nitric acid. On the large scale an impure acid is made by the action of sulphuric acid on bone ash (*q.v.*), $Ca_3(PO_4)_2 + 3H_2SO_4 = 3CaSO_4 + 2H_3PO_4$. *Pyrophosphoric acid*, $H_4P_2O_7$, is an indistinctly crystallised solid. It is soluble in water, and its solution slowly—quickly when warmed or in presence of a strong acid—changes to orthophosphoric acid; it is a tetrabasic acid. The silver salt is white. It is obtained as mentioned above or from its sodium salt (which is formed by heating common sodium phosphate) by precipitation with lead acetate, and decomposition of the lead salt with sulphuretted hydrogen. *Metaphosphoric acid*, $H_2P_2O_6$ (Glacial phosphoric acid), a glassy or ice-like solid; deliquescent; vapour density accords with the formula $H_2P_2O_6$; its solution changes just like that of the pyrophosphoric acid, to orthophosphoric acid; it gives a white silver salt, and coagulates albumin. It is obtained by strongly heating either of the two preceding acids; also by the action of water on phosphoric oxide. The more important phosphates are described under the compounds of the corresponding metals. Phosphorus unites with alcohol radicals just as nitrogen does to form compounds like the amines. Thus, triethyl phosphine, $P(C_2H_5)_3$, and tetra-ethyl phosphonium iodide, $P(C_2H_5)_4I$, are obtained by heating phosphonium iodide with ethyl iodide under pressure.

Phosphotungstic Acid (*Chem.*) *See* TUNGSTEN AND ITS COMPOUNDS.

Photo Chemical Effects. Chemical changes produced by the action of light. *See* PHOTOGRAPHY, *etc.*

Photochromy. The reproduction of colours by photography. *See* PHOTOGRAPHY IN COLOURS.

Photochronograph (*Astron.*) A small apparatus fitted to the eye end of a transit instrument for recording photographically the transit wires, the time, and the star trail.

Photo Engraving. The production of engraved plates by means of photographic processes. Trade terminology has divided photo engraving into three classes. (1) PROCESS: The production of typographic printing blocks (halftone blocks) from ordinary photographs, wash drawings, etc. (2) PHOTO ENGRAVING: The production of relief plates for use with type, from black and white subjects in *pure line*. (3) PHOTOGRAVURE: Intaglio plates on copper (afterwards faced with steel) for the reproduction of paintings, etc., in monochrome. The first and second have displaced wood engraving and, to some extent, lithography. The third has largely replaced mezzotint engraving and steel plate engraving. The reproduction of subjects in pure line is practically coeval with the art of photography, the Ordnance Survey Department having employed photo engraving for the reproduction of maps and plans soon after the introduction of photography. The production of halftone engravings was not accomplished until about half a century later. (1) HALFTONE ENGRAVINGS: In reproducing photographs or wash drawings the result is obtained by breaking up the continuous tone of the original into stipple or grain, the process being as follows: A *negative* is made from the original on a wet collodion plate or on a dry gelatine plate, the former being much more commonly used; but at a short distance in front of the sensitive plate is placed a transparent screen, formed of two sheets of glass cemented together with Canada balsam, both sheets being ruled and placed so that the lines cross each other. The lines are absolutely opaque, and vary in number according to the purpose for which the work is required, *e.g.* 80 lines per square inch are used for a coarse grain block, and up to 200 or more for fine art illustrations. The screen causes the highlights of the original to be represented on the negative as round transparent dots, which gradually enlarge as the tone of the original darkens. A pure halftone resembles a chessboard pattern of opaque and transparent perfect squares. Continuing the ratio of tone, the transparent squares gradually enlarge, until the darkest parts of the original are represented by minute opaque pin points. A copperplate, prepared by polishing with charcoal or precipitated pumice powder, is then sensitised by coating with an even film of bichromated fish glue. Light acting upon this compound renders the substance insoluble in cold water. A positive image is therefore obtained by placing the negative in contact with the sensitised metal surface, and exposing in a pressure frame to the electric "arc" or sunlight, the length of time varying from one to thirty minutes, according to the degree of sensitiveness of solution, the quality of negative, and the actinic power of the light. After exposure, the plate is put into a tray of cold water to develop, and every part of the film upon which light has not acted, owing to the opaque portions of the negative, is readily dissolved. The result is an invisible positive image, rendered insoluble by the light passing through the transparent parts of the negative. The image is at once made apparent by staining the film with a weak solution of aniline dye, which is allowed to flow over it. After drying, the metal plate is slowly and evenly heated to a temperature of about 340° to 400° C., the insoluble image of soft glue being thereby converted into a hard carbonised film. When cool the plate is immersed in an etching mordant of ferric perchloride, ranging in strength from 25° to 48° Beaume, the carbonised image resisting the dissolving action of the mordant, whilst the intervening spaces and points of bare metal are readily attacked. From two to five minutes are sufficient to etch the plate to a suitable depth, so that the image may be left in relief. Theoretically, an impression from this plate should be a facsimile of the original; but the process has to be modified to meet certain technical difficulties, one of these being that the lighter tones of the original are rendered more or less dull through the interposition of the cross lined screen, thus causing a diffused shadow to be thrown over those parts on the negative. This is remedied by passing the plate on to a "Fine Etcher," who, being possessed of some artistic ability, covers those tones which, on the copperplate, are correspondingly correct with the original, with an acid-resisting varnish. It is then again immersed in the etching mordant. If necessary, the process is repeated by covering the next lighter tones and further etching. The intervening spaces between the carbonised film are thus gradually etched wider, until the highest lights of the original are (if white) represented by minute pin points, or, in some cases, etched or cut away altogether. An impression on paper may be obtained by inking the plate with a gelatine roller charged with letterpress ink and passing it through a press. After cutting away the surplus edges by special machinery, the plate is mounted on oak or mahogany wood, and

planed to a certain gauge, so that any block may be printed with any type matter in an ordinary typographic machine. (2) A similar method is used for reproducing LINE DRAWINGS, but the absence of tone does away with the necessity of using a screen. The metal generally used is zinc, and the etching mordant, nitric acid, varying in strength from one or five to twenty parts water. The sensitive film also differs in that bichromatised albumen is generally used. After coating the plate with the sensitive solution and exposing to light, the plate is inked over by means of a gelatine roller with a very thin film of lithographic transfer ink, and developed by placing in a tray of cold water, the action of light on the albumen film also rendering it insoluble. By gently rubbing with a tuft of cotton wool, that part unacted upon by light is washed away, leaving an insoluble image of the line drawing thinly coated with a greasy film of ink. Finely powdered bitumen is then dusted over, and adheres to the ink. After carefully washing off excess of powder and drying, the plate is gently heated, the bitumen melting and forming with the ink a firm acid resisting image. After cooling, the image is obtained in slight relief by immersing for a short time in a weak aqueous solution of nitric acid (one part to twenty parts water). The image is further protected by rolling over another coating of fatty ink by means of a lithographic "nap" roller, and dusting with resin and resinous powder, commercially known as "Dragon's blood." After heating sufficiently to melt the resinous film and cooling, the plate is further etched, the process being repeated with increasingly stronger acid until the image is in sufficient relief for printing in press. A different resist from that used for copper is employed because the high temperature necessary to carbonise a film of fish glue would change the structure and properties of zinc, the latter metal being readily powdered at a temperature of 300° and melting at 420° C. (3) PHOTOGRAVURE: This is a general term for the various processes for producing plates for printing purposes which are the reverse of (1) and (2), *i.e.* the engraving is in *intaglio* instead of "in relief." As in the case of (1) and (2), bichromatised gelatine is the medium by which the plate is produced. A cloud of bitumen dust is allowed to settle on a plate placed inside a cabinet, the grains of bitumen being afterwards fixed to the plate by heat. The bichromatised gelatine film is now placed over this surface, and the subject printed upon it through a glass positive. The hardening process is effected by means of light, the unhardened portions being afterwards washed out. *See* (1) HALFTONE ENGRAVING. The plate is next immersed in perchloride of iron for the purpose of being etched, and is finally finished by a retoucher. Plates may also be prepared by using a grain screen instead of bitumen powder; but the result is not so satisfactory in the case of fine work. Photogravure reproduces the tones of the original drawings, etc., much more satisfactorily than the processes previously described, but the cost of producing the plates is much greater. A commercial TRICOLOUR ILLUSTRATION is produced by superimposing three prints one over the other from three halftone blocks, yellow, red, and blue, in their respective colours, resulting in a correct colour rendering of the original from which the blocks were made. The method generally employed is that known as the "direct" process. Three light filters, usually of dyed collodion, representing the three primary colours—red, green, and violet (*see* COLOURS)—are placed successively behind the lens, and three separate negatives, made on dry gelatine plates or collodion emulsion, are taken from the coloured original, the cross lined screen being placed in front of the sensitive plate, as in the case of black and white tone work. The red filter transmits all rays of light reflected from the original with the exception of its complementary colour, blue. A positive print made from this negative and etched on copper is therefore printed in the press with blue colour. The green filter has a similar action in suppressing the complementary colour, red, the block made from this negative being printed with red. The violet filter likewise suppresses the yellow, the subsequent block being printed in that colour. To prevent patterning of the screen in the three superimposed colour prints on paper, the angle of screen is so arranged that the lines for the yellow negative are crossed by those of the red at an angle of 60°, and by those of the blue at 120°. This is generally attained by adopting a revolving copy board, so that the original, instead of the screen, can be moved to the required angle for each negative. The method for etching and finishing the block is identical with that in use for ordinary black and white work.

Photographic Camera. A photographic camera consists essentially of a dark chamber. At the back is placed the sensitive plate, and in the front is the lens by which the image is projected on to the sensitive plate. The simplest type is the FIXED FOCUS CAMERA, which may be merely a rectangular box, the plate being supported by some suitable device at the end. Most cameras, however, possess some arrangements for focussing, or varying the distance between the lens and plate in order to secure a sharp image. The body is then made in two or more parts, one of which may slide in and out of the other; or the two parts may be connected by a bellows, a light-tight folding portion composed of leather kept in shape by internal strips of cardboard or other stiffening material. The operation of focussing is effected in this case by moving the front, to which the lens is attached by means of a rack and pinion. The open back carries a ground glass FOCUSSING SCREEN, on which an image is produced which is visible to the operator. When this image is in focus, the opening of the lens is closed by a cap or shutter; the screen is replaced by a DARK SLIDE, a flat box carrying the plate, shut in by a sliding cover. When placed in position the slide is withdrawn, and the surface of the plate occupies the position previously occupied by the surface of the screen. On opening the shutter or cap of the lens the image is produced on the plate. The best types of camera have a RISING and FALLING FRONT, whereby the lens may be raised or lowered, and also a SWING BACK, by which the dark slide and the contained plate may be brought into a vertical position if it be necessary to tilt the camera. This prevents the distortion of the image which would otherwise occur by pointing the camera upward or downward, and is essential in photographing architectural objects. A FOLDING CAMERA is one in which the bellows can be compressed into a small space, bringing the back and front close together, in order that great portability may be obtained. A MAGAZINE CAMERA is one in which a number of plates or films are contained, some mechanical device being fitted to enable a fresh plate to be placed in position after an exposure has been made, and the exposed plate to be removed to a position in which it will no longer be acted on by

light. Various devices are now in use by which DAYLIGHT LOADING is effected, *i.e.* a fresh supply of films can be introduced and the exposed ones removed without a darkroom. There are two main ways of doing this. In the first method the films are cut to size and arranged in a pile like a pack of cards, each film being separated from the next by a sheet of black paper; the whole pile is protected by a light-tight covering, which can be removed after the films are introduced. In the second, which is the more popular method, the film is made in a continuous sheet, and rolled up on a reel in contact with a sheet of black paper, of which the ends are left long enough to furnish several turns round the outside of the spool, in order to exclude light. The spool is placed inside the camera, and the film wound off on to another reel as required for each exposure. When all the film has been exposed, the second reel is full, and the film is again protected by several layers of the black paper, enabling the exposed film to be removed with safety. *See also* PHOTOGRAPHY *and* PHOTOGRAPHY IN COLOURS.

Photographic Telescope (*Astron.*) A telescope so arranged that the photographic plate replaces the eye.

Photography. The art of obtaining images by the chemical agency of light upon sensitive substances. The darkening effect of light on silver chloride was noticed by the alchemists in the sixteenth century, and furnished a good example of photographic action, the nature of which was afterwards investigated by Scheele. The first attempts to practically utilise the darkening of silver salts by light appears to have been made by Wedgwood and Davy about 1802. A sheet of white paper or leather was coated with a strong solution of silver nitrate and dried, the objects intended to be copied being either placed in contact or their shadows projected upon it. Upon exposure to sunlight, the parts protected by the objects remained white, while those surrounding them darkened under the influence of the sun's rays. Experiments of this and similar natures were, however, rendered comparatively valueless from the want of means for fixing the images, and so preventing any further action of light from taking place, the unaltered silver salt remaining in the white portions of the paper gradually darkening. In many cases, however, the action of light is invisible, and agents technically known as developers have to be employed to bring the minute change effected by light to the cognisance of our senses. In the Daguerreotype process, where an invisible action of light is produced on a silvered copperplate, rendered sensitive by exposure to the vapour of iodine, the development is accomplished by means of mercury, the vapour of this attaching itself to the substance altered by light, but whether from a physical or chemical cause is uncertain. In the process patented by Fox Talbot in 1841, under the name of Calotype, in which the sensitive material consists of silver iodide formed upon paper, the development was effected by means of gallic acid, a method discovered by the Rev. J. B. Reade. Owing to the suggestion of M. Le Gray, of Paris, of the possible use of collodion in photography, and its practical application by Scott Archer in 1851, such a stimulus was given to the progress of the art that it soon began to assume the importance it has since attained. In this collodion process, a glass plate, coated with collodion containing iodides and bromides of metals or alkalis, is immersed in a solution of silver nitrate, a sensitive surface consisting of iodide and bromide of silver being thus formed. The plate is then exposed wet in the camera, and the image afterwards developed by means of an acid solution of pyrogallol or sulphate of iron, the silver reduced from the silver nitrate present being deposited upon the parts altered by light. Although very fine photographs can be obtained upon wet collodion, the necessity of preparing the plates at the moment required, and obtaining the finished results without delay, are disadvantages, and the process (except in the case of certain classes of work) has long been superseded by the use of gelatino bromide dry plates, the sensitiveness and keeping properties of the latter rendering them available in cases that are practically impossible with the former. With dry plates and those which do not contain silver nitrate, a method of developing the invisible image, known as alkaline development, is employed, in this case the developer directly acting upon those parts affected by light, and so reducing the sub-salt of silver forming the invisible image to metallic silver. This in its turn combines with silver bromide to form mechanically fresh sub-bromide, which becomes reduced by the developer as before. And if the image be a negative one, such as results from exposing a plate in the camera under ordinary conditions, it would, when viewed by transmitted light, show all the lights and shades in the objects represented, reversed. After the image has been developed, an operation technically known as fixing is employed to remove the unaltered silver salts from the film. In the wet collodion process this is usually accomplished by means of potassium cyanide, but in the case of gelatine plates sodium thiosulphate (hypo) is used instead, owing to the danger of cyanide attacking the half tones. It frequently happens, especially with gelatine plates developed with some of the recent developers, that the negative after fixing is found to be too thin for printing, and resort has to be had to intensification. There are various methods in use for this purpose, those with mercury usually being employed with gelatine plates. The image, being bleached in a solution of mercuric chloride or bromide, is well washed, and converted into a grey or black colour by means of a solution of sodium sulphite, ammonia, silver cyanide, or a ferrous oxalate developer, this latter offering the extra advantage of permanency in the intensified image. Of methods for reducing the opacity of negatives, that with potassium ferricyanide and hypo is perhaps most generally used, although for reducing the contrasts in them a 2 per cent. solution of ammonium persulphate is found valuable. From the observations of Dr. Vozel in 1873, that the addition of dyes to silver salts increased their sensitiveness to certain colours, we owe a discovery of very considerable importance, and one which has since received practical application in the use of orthochromatic plates. In order, however, to obtain any appreciable difference in the results when using them for ordinary work by daylight, a yellow screen must be employed to cut off some of the blue rays, as the sensitiveness to blue and violet still predominates. The selection of this screen is a matter of importance, since if it be too deep in colour it may cut off the blue and violet entirely. For the best results it should be one that is adjusted to the plate. When this is not the case, it is perhaps advisable that the one chosen should not require an increase of exposure of more than six or eight times. A screen can often be employed

with advantage in hand camera work, although in most cases it must not more than double the ordinary exposure required. Of the various printing processes, those in which the image is printed out on gelatino chloride, collodio chloride, or albuminised papers, and afterwards toned with gold, are largely used, while the numerous development papers offer the great advantage of rapidity in the production of the prints. For permanency, however, platinum and carbon stand unrivalled. Modifications of the carbon process have been introduced under the names of Artigue and Ozotype, in which the image is printed direct upon its final support. The former, however, while yielding very fine results, requires a good deal of care in manipulation, while the latter only needs that necessary in carbon printing generally. —E. S.

Photography in Colours. The methods by which objects can be represented photographically in colours may be classed under two heads: (1) The direct method, in which a light-sensitive substance is capable of reproducing the colours which fall upon it. (2) The indirect method, which is dependent upon the superposition of coloured images (usually three), and which is known as the three colour process. DIRECT METHOD: The colours are due either (1) to interference, as in the case of the Becquerel and Lippmann process, or (2) when paper coated with silver chloride is used, such as Seebeck employed, are of a pigmentary nature. In this process of Dr. Seebeck, which dates back to 1810, a solar spectrum was projected upon paper prepared with moist silver chloride, and an image obtained somewhat resembling the spectrum colours. The chief worker, however, in this subject, M. Edmond Becquerel (the first published account of whose work appeared in 1848), obtained his best results upon chlorinated silver plates, the particular method of chlorination adopted being that in which the chlorine was produced by the electrolysis of dilute hydrochloric acid, the nascent chlorine uniting with the silver. This method had the advantage of greater control over the thickness of the film of chloride formed, as when the violet colour was assumed for the second time the silver plate was removed from the bath, washed in distilled water, and dried at a gentle heat, the plate being then sensitive to all spectrum tints. The colours are, according to Wiener, partly pigmentary and partly due to interference. A great disadvantage attending this process was that the coloured images could not be fixed. By far the most important method of producing direct photographs in colour is that due to Professor Gabriel Lippmann, and first announced by him in 1891, and is based on the theory and work of Zenker and Wiener. The process, which is very simple, consists in employing a plate of glass coated with a perfectly transparent sensitive film of silver bromide in gelatine, together with suitable colour sensitising dyes, and having in contact with the film during exposure in the camera a metallic mirror in the form of a layer of mercury. The latter is for the purpose of reflecting the light back upon itself. This gives rise to stationary waves within the film, with the result that, after development and fixing, the image is formed of a laminated deposit of silver, separated by transparent layers of gelatine, the thickness of each transparent layer being equal to half the wave length of the light used during exposure. When these photographs are viewed by white light incident normally upon them, waves equal in length to those used during exposure will be reflected back to the eyes, and thus the film will appear of the same colour as the light to which it had been exposed. When viewed obliquely the colours change, red becoming successively yellow, green, and blue. To enhance the brilliancy of these photographs, and at the same time eliminate disturbing surface reflections, a shallow glass prism is usually cemented to the film with Canada balsam. The INDIRECT METHOD of colour photography is based on the theory of Dr. Thomas Young, who found that any colour could be produced by the mixture in various proportions of three colours properly chosen. Professor Clerk Maxwell, who supported this theory, appears to have first suggested how to carry it into practice by the aid of photography in a lecture delivered at the Royal Institution on May 17, 1861. The particular colours to employ, and the proportions in which they must be mixed to represent all intermediate spectrum hues, was first determined by Maxwell, and are shown in his famous diagram of colour mixture curves. These curves have quite recently (1899) been re-determined by Sir William Abney, whose results differ somewhat from the former; and the three simple colours which, when mixed in suitable proportions, will reproduce to the eye the sensation of every other spectrum colour, have been found to be: a red situate about the lithium line in the red; a green near the E line in the green; and a blue violet about the blue lithium line. In order, therefore, to obtain a three colour photograph of the spectrum, three photographs must be taken, in each of which photographic action must be so distributed that it would be represented graphically by the respective curves in one of these diagrams. In order to realise this in practice, the negatives are taken through light filters (colour screens), which should transmit light in accordance with the colour curves; such light filters, if they enable correct colour records of the spectrum to be obtained, should answer equally well in the case of landscapes, or coloured objects generally, since their colours are only mixtures of spectrum colours. As these filters require to be adjusted to suit the sensitiveness of the plates employed, they can only be described in general terms as being red, green, and blue violet in colour. Positives made from the negatives taken by their use, when backed by media allowing only pure colour to pass, will, when their images are superimposed on a screen, reproduce the colours of the original; but if prints are to be produced, the prints must be made in colours which are complementary to the three colour sensations. These principles appear to have been recognised by Louis Ducos du Hauron in 1868. To Mr. F. E. Ives, however, must be given the credit of bringing the process to the state of perfection it has now reached. He pointed out the necessity of using screens which transmit pure colour only for correct synthesis, as distinct from the colour curve screens used in taking the negatives; and by means of his ingenious viewing apparatus the kromscop completed a most perfect method of composite heliochromy. When finished prints for use as transparencies or projection in a single lantern are required (a system of three colour photography brought to such perfection by Sanger Shepherd and Messrs. Lumière), the positives are usually made upon gelatino bromide celluloid films sensitised with bichromate, and after development and fixing are stained the complementary colours in aqueous solutions of dyes. In the case, however, of the positive from the red record negative, it is found better to make this upon a lantern plate, and convert it into the required blue colour with potassium ferricyanide, followed after washing with ferric

chloride. The films are then cemented together between glasses, and form a finished transparency in colours. A method suggested by Dr. Hauron in 1869 for obtaining the three colour records on one plate, and put into practice by Professor Joly, of Dublin, consists of exposing the photographic film in contact with a glass plate placed in front of it, ruled in transparent coloured inks, with red, green, and blue violet lines. These coloured lines, which correspond to the colour filters used in taking the record negatives in Ives's process, number about 260 to the inch, and the order in which they are ruled is repeated throughout the plate, which by transmitted light appears of a light grey colour. Negatives taken through such a screen will be crossed by a series of lines of deposited silver corresponding to the amount of light which acted through the respective lines, and a positive made from such a negative when placed in contact, and "correct register" with a similar lined screen, but ruled in colours which stimulate respectively the three colour sensations of the eye, will, when viewed directly, show the image in colours. A variation of the three colour process, due to Professor R. W. Wood, which does away with the necessity of using coloured screens or pigments for the finished pictures, consists in employing three diffraction gratings, each ruled with such a number of lines to the inch that, when superposed in front of a lens, they will send red, green, and blue light to the same spot on a screen behind it, which by their mixture will convey to the eye the sensation of white light. To produce a picture in colours by this method three negatives are taken through red, green, and blue violet colour filters as usual, and from these positives are made on lantern plates. A piece of glass coated with bichromated gelatine (or albumen) is placed with its sensitive film in contact with a grating bearing 2,000 lines per inch, and the whole covered with the positive representing the action of the red light. An exposure of a few seconds to sunlight will impress the lines of the grating on the bichromated film under the transparent parts of the positive. The second grating, consisting of 2,400 lines per inch, and the positive, representing the action of the green light, are now substituted for the others, and a second exposure given. The same is then repeated for the blue, using a grating having 2,750 lines per inch, and the positive which represents the blue. The plate is then washed for a few minutes in warm water, and on drying the image appears as a coloured photograph when placed in front of a lens and viewed through an aperture in a screen. The finished picture, which is perfectly transparent, merely consists of a diffraction grating on gelatine, with variable spacing. Some progress has also been made towards realising in practice Wiener's idea for an ideal colour sensitive surface, in which three films stained red, blue, and yellow with fugitive dyes, are combined to form a black or neutral tint. Such a surface will, with prolonged exposure, under a coloured transparency, yield a more or less perfect reproduction of the coloured image. A means of thoroughly fixing these images, however, still remains to be found.—E. S.

Photometers. A photometer is an instrument for comparing the illuminating powers of two sources of light. All such instruments in common use depend upon the fact that the eye is capable of judging with considerable accuracy when two surfaces adjacent to each other are equally illuminated. It is necessary that the illumination observed shall be due to the two sources only, and therefore all other light must be excluded, the measurements being made in a darkened room or other enclosure, the inside of which should be blackened, to prevent reflected and diffused light from interfering with the observations. The source of light to be tested is usually fixed at one end of a horizontal bench or bar, termed the PHOTOMETER BENCH or BAR, which is graduated in inches or centimetres; at the other end is fixed a standard light, which may be a STANDARD CANDLE, PENTANE LAMP, METHUEN SCREEN, etc. (*q.v.*) At a point between the two lights is fixed the PHOTOMETER proper. Let I be the intensity of one of the two sources, then at a distance d the intensity of illumination is $\frac{I}{d^2}$. If I_1 and I_2 be the relative intensities, d_1 and d_2 the distances of the two sources from the photometer, then when the latter is receiving the same amount of light from each source,

$$\frac{I_1}{d_1^2} = \frac{I_2}{d_2^2}, \text{ or } \frac{I_1}{I_2} = \frac{d_1^2}{d_2^2}$$

The form of photometer most used in practice is BUNSEN'S PHOTOMETER (*q.v.*) Observations with this instrument are usually made with the aid of two mirrors placed behind the screen, and inclined at 90° to each other and at 45° to the screen; by this means both sides of the screen may be viewed at the same time, and the position of the photometer with reference to the two sources adjusted with considerable accuracy until the spot appears of the same brightness as the rest of the surface of the screen. JOLY'S PHOTOMETER consists of two flat plates of translucent paraffin wax placed in contact, with a sheet of tinfoil between them. When placed between two sources of light and viewed edgewise, each plate appears to be illuminated; when both appear equally bright, the intensities of the two lights are proportional to their distances from the screen. The LUMMER-BRODHUM PHOTOMETER consists of an opaque white screen, one side of which is illuminated, by each of the sources of light which are being compared. An ingenious arrangement of mirrors and reflecting prisms enables the central portion of one surface of the screen, and the outer portion of the other, to be viewed at one time. If the two sides of the screen are not equally illuminated the eye sees a bright patch surrounded by a dark zone, or *vice versa*. Adjustments are made until the inner and outer zones are equally illuminated. When this is the case the two surfaces must be equally illuminated, and therefore the intensities of the two sources are proportional to the square of their distances from the screen. A simpler arrangement, which possesses the advantage that it may be used in a room which is not quite dark, is RUMFORD'S SHADOW PHOTOMETER. This consists of an opaque rod, a shadow of which is cast on a white screen by each of the two lights, which are moved backwards and forwards until the intensities of the shadows are the same. The intensities of the lights are then proportional to the square of their distances from the screen.

Photometry (*Light*). The comparison of the intensity of a given source of light with a standard source by means of a PHOTOMETER (*q.v.*)

Photomicrograph. A photograph of a microscopic object obtained by attaching the camera to the microscope tube.

Photospectro Heliograph (*Astron.*) An instrument for recording photographically a picture of the

sun's disc and limb in colour of one wave length or monochromatic light. The "K" line of calcium is the light usually employed.

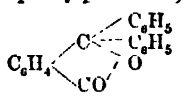
Photosphere (*Astron.*) The sun's visible surface.

Phototype. A general name for copying processes based upon photography. *See* BLUE PRINT.

Phrase (*Music*). The subdivisions of a musical sentence or period are called phrases, two or more of which form a period.

Phrygian Mode (*Music*). *See* MODES.

Phthaleins (*Chem.*) Substitution products of phthalophenone (diphenylphthalide),

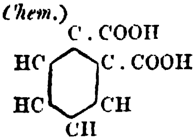


But the Phthaleins are not usually prepared from phthalophenone; they are prepared by heating phenols with phthalic anhydride in presence of a dehydrating agent, such as sulphuric acid or zinc chloride. For examples of phthaleins, *see* PHENOL-PHTHALEIN, FLUORESCEIN, EOSINE. That phthalophenone has the constitution assigned to it is proved by its synthesis by Friedel and Craft's reaction (*q.v.*) from phthalylchloride and benzene:

$$C_6H_4 <\begin{matrix} C.Cl_2 \\ CO \end{matrix}> O + 2C_6H_6 = C_6H_4 <\begin{matrix} C(C_6H_5)_2 \\ CO \end{matrix}> O + 2HCl$$

Also phenol-phthalein (*q.v.*) can be synthesised from phthalophenone by nitration, reduction, and diazotisation. The RHODAMINES (*q.v.*) are also Phthaleins.

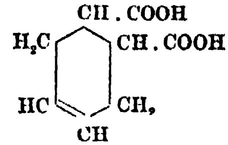
Phthalic Acid (*Chem.*)



A colourless crystalline solid (prisms); melts at 203° if quickly heated, and forms the anhydride with loss of one molecule of water:

$$C_6H_4 <\begin{matrix} COOH \\ COOH \end{matrix} = C_6H_4 <\begin{matrix} CO \\ CO \end{matrix}> O + H_2O.$$

Sparingly soluble in cold water; readily soluble in hot water and in alcohol. It is a dibasic acid, forming two classes of salts and esters. Heated with soda lime it gives first benzoic acid, then benzene. It is prepared by oxidising naphthalene tetrachloride with nitric acid. *See* p. 447. It is also prepared, in the form of its anhydride, on a large scale for the preparation of indigo. *See* INDIGO. Phthalic acid can unite with two, four, or six hydrogen atoms, and so give rise to many hydrophthalic acids; thus, theoretically it would give six dihydrophthalic acids. Of these, four are known: the $\Delta^{3,5}$-dihydrophthalic acid (*see* NOMENCLATURE) can exist in two forms, known as the cis- and trans-forms. The cis-$\Delta^{3,5}$-dihydrophthalic acid has the two carboxyl groups on one side of the benzene ring, while the trans- acid has them on opposite sides. The cis- acid readily forms an anhydride; the trans-acid forms an anhydride with difficulty, and the anhydride formed is that of the cis- acid. The trans-$\Delta^{3,5}$-dihydrophthalic acid is obtained by reduction of phthalic anhydride in acetic acid solution by sodium amalgam; it passes into the cis- acid on heating with acetic anhydride. Three tetrahydrophthalic acids are known, of which the Δ^4 compound,



is known in the cis- and trans- modifications. The hexahydro acid is known in the cis- and trans- forms, and the latter, which contains an asymmetric carbon atom, can be resolved into its optically active components by means of quinine. *The anhydride of phthalic acid*,

$$C_6H_4 <\begin{matrix} CO \\ CO \end{matrix}> O,$$

forms long, shining, needles; melts at 128°; boils at 284°; slightly soluble in water; very soluble in alcohol and ether. On heating, it easily sublimes. Alkalis readily form salts of phthalic acid with it. With one molecular proportion of phosphorus pentachloride on heating it gives phthalyl chloride, which behaves in many of its reactions as if it has the constitution

$$C_6H_4 <\begin{matrix} C.Cl_2 \\ CO \end{matrix}> O;$$

e.g. with zinc and acetic acid it yields phthalide,

$$C_6H_4 <\begin{matrix} CH_2 \\ CO \end{matrix}> O$$

See also PHTHALEINS. Heated with phenols, the anhydride gives Phthaleins (*q.v.*) The anhydride is obtained by heating phthalic acid alone or with acetyl chloride. *Phthalimide*,

$$C_6H_4 <\begin{matrix} CO \\ CO \end{matrix}> NH,$$

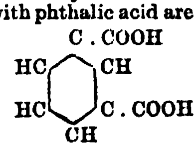
is a white crystalline solid (prisms); melts at 229°; soluble in ether; sublimes on heating. With alcoholic potash it forms a well crystallised potassium salt, potassium phthalimide,

$$C_6H_4 <\begin{matrix} CO \\ CO \end{matrix}> NK$$

This salt reacts with alkyl iodides, forming alkyl phthalimides, which are converted by alkalis into phthalates and primary amines:

$$C_6H_4 <\begin{matrix} CO \\ CO \end{matrix}> N.C_2H_5 + 2HOK = C_2H_5NH_2 + C_6H_4 <\begin{matrix} COOK \\ COOK \end{matrix}$$

For a very important reaction of phthalimide, *see* INDIGO. Phthalimide is obtained by heating phthalyl chloride or phthalic anhydride in a stream of ammonia gas. Isomeric with phthalic acid are isophthalic acid,



and terephthalic acid; the former is not an important compound, the latter is treated by itself. Neither of the isomers of phthalic acid forms an anhydride.

Phyllite (*Geol.*) A rock of argillaceous composition, and usually of sedimentary origin, which

has been subjected to dynamic metamorphism, with the result that the microscopic fragments of potash felspar occurring in the parent rock have been paramorphosed into flakes of Muscovite, which have a common orientation throughout the rock, and thus facilitate its separation into thin sheets in the same manner as slates. These scales or flakes of mica usually impart a peculiar silky lustre to the face of a phyllite which has been split up by mechanical means.

Phylloporphyrin (*Chem.*) $C_{16}H_{18}N_2O$. A decomposition product of chlorophyll. It forms short reddish violet prisms; soluble in chloroform; less soluble in ether or alcohol; gives red fluorescent solutions. It shows an absorption spectrum of seven bands, which closely resembles that of hæmatoporphyrin from hæmoglobin (*q.v.*), and it appears to differ from this substance only in containing two oxygen atoms less; corresponding to this phylloporphyrin is insoluble in aqueous alkalis, while hæmatoporphyrin is readily soluble. Like hæmatoporphyrin (*see* HÆMOGLOBIN), it yields as products of oxidation and reduction respectively hæmatinic acid and hæmopyrrol. The compound mesoporphyrin (*see* HÆMOGLOBIN) is intermediate between phylloporphyrin and hæmatoporphyrin.

Physical Astronomy. The branch of astronomy dealing with the composition, temperature, etc., of heavenly bodies. It owes its existence almost entirely to observations by the spectroscope. *See* SPECTRUM ANALYSIS.

Physical Isomerides. A name given to compounds which have the same constitutional formula, and therefore the same chemical reactions, but have different physical properties. The difference in physical properties is caused by the different spacial arrangements of the atoms or atomic groups in these compounds. *See* STEREOISOMERISM.

Physics. The term Physics originally referred to the study of Nature and natural phenomena in general; it is now restricted to the study of the properties of matter and of natural forces and phenomena which are neither organic nor chemical in their nature. There is no hard and fast boundary line, however, between physical and chemical phenomena.

Physio-Chemical Engineering. ORIGIN AND HISTORY: Throughout this Dictionary a number of definitions are given under the classification of *Chem. Eng.*, and some explanation of this classification is necessary. The term is a shortened form of what is really Physio-Chemical Engineering, a profession, or branch of the engineering industry, which has only been recognised during the last fifteen or twenty years. Strictly speaking, it is an offshoot of engineering which has arisen out of the needs of the chemical industry, and finds a parallel in electrical engineering, though perhaps there is more engineering than electrical knowledge required for the latter, while in chemical engineering there is need for a more general knowledge of each component. On the other hand, so-called chemical engineering is of a more complex nature than the name implies, and for this reason it is thought preferable to deal with the subject under Physio-Chemical Engineering. The present Society of Chemical Industry started as a Society of Chemical Engineers, but the title was thought to be too exclusive at that time. The need for a chemical engineer arose out of the industrial developments of chemistry. Processes were worked out in the laboratory, but when it came to working on a manufacturing scale, glass vessels and indiarubber tubing were inapplicable. The mechanical engineer had to devise and construct as best he could suitable plant and apparatus with which to carry out processes on a large scale. In time it became evident that many processes were impracticable for want of better chemical plant. The chemist consulted the engineer, and the latter endeavoured to construct what was needed. Seeing the scope afforded, some men specialised and made themselves acquainted with all that engineers were doing or had done, and applied the knowledge so acquired. Hence the chemical engineer. Since then there has been much controversy as to what are the qualifications of a chemical engineer. There is little doubt, however, that a knowledge of chemistry and physics is of more importance than detailed knowledge of mechanical engineering, though a practical acquaintance with the latter is a great help, and some knowledge essential. DEFINITION: To define Physio-Chemical Engineering is obviously no easy task. The definition must necessarily be rather involved, as it includes a knowledge of chemistry, physics, civil and mechanical engineering. Perhaps the most concise definition is this: The adaptation of materials to methods, in doing which the three chief qualifications are common sense, observation, and ingenuity. APPLICATIONS: Physio-Chemical Engineering deals with the manipulation, control, and transport of the gases, liquids, and solids which result from or are essential to chemical reactions on a manufacturing scale. These bodies may be hot or cold, inert or corrosive, volatile or stable, as well as explosive or inflammable. An accurate knowledge of their chemical and physical properties is necessary before suitable plant for their manipulation can be evolved. In the same way constructional details have to be modified to meet the various methods for their solution, decomposition, lixiviation, precipitation, filtration, evaporation, distillation, concentration, or condensation. This involves a study of the materials which will withstand the forces exerted by such gases, liquids, and solids while undergoing chemical change and the consequent variations in their physical conditions. It will be seen, therefore, that Physio-Chemical Engineering is a very extensive branch of engineering, and is not easily defined, more particularly as in this relationship chemistry and engineering are so largely interdependent. Undoubtedly to the chemical engineer is due the evolution of certain plant and apparatus which otherwise might never have been thought of. The filterpress, centrifugal dryer, steam trap, and Montejus or acid egg, are four striking examples. In the first two the engineer turned well known forces to account. The development of steam coils for heating in all branches of chemical industry created a demand for an effectual means of removing condensed steam without letting live steam escape; while in the transport of corrosive fluids the lead-lined acid egg took the place of the old type of pump, with compressed air substituted for the plunger or piston. As the result of these changes the engineer on the mechanical side perfected the existing air compressing and exhausting engines, and enabled the manufacturer to use compressed air, vacuum pans, and multiple effect evaporation with economy. Yet chemical knowledge is largely fundamental in effecting improvements. In the aniline dye industry the supply of concentrated vitriol to almost every department of the works is necessary. Cast iron pipes and compressed air exist, but it needs the reassurance of the chemist that cast iron is

practically unattacked by strong vitriol (although dissolved by weak) before the engineer is able to employ the two, and so transport the acid to any part of the works with ease and safety. In the same way the chemist has co-operated with the engineer in producing acid-resisting alloys or other material for taps, valves, packings, washers, and other engineering accessories suitable for chemical plant. Disintegrators, mechanical agitators, steam jet heaters and agitators have also been adapted to the special requirements of chemical engineering. The soap industry, however, affords an excellent example of how purely engineering skill has been devoted to the production of special plant (for which only a knowledge of physics and engineering was essential), notably in connection with the cooling, drying, shredding, and milling of soap. The introduction of carborundum also affords an instance of how the electro chemist comes to the aid of the chemical engineer by providing an acid and heat resisting material for furnace linings and allied uses. It is not possible in a short review such as this to do more than indicate thus the varying phases of chemical engineering, in order to show how comprehensive the term is, and consequently so difficult to define. In the future it is probable that the term will become as generic as that of civil engineering, and include a number of industries in which chemical plant is used, but which are known by the name of the actual product produced. For instance, the gas engineer is largely a chemical engineer, or should be: but, owing to the present magnitude of this particular industry, the title of Gas supplants the more general one of Chemical. LITERATURE: There is very little available literature *per se*, as most of it is to be found in articles contributed to almost all classes of technical journals. Chemical engineering itself, even then, is seldom kept separate from works' management, organisation, and administration, but is dealt with only in so far as equipment bears upon these subjects. As for text books they can hardly be said to exist. For many years trade catalogues constituted the nearest approach to anything of the kind, and even now are often the best source of information. Of late the pick of such catalogues has been collected, classified, and occasionally supplemented by notes, and then presented in this condensed form as a handbook. Useful as this handier form undoubtedly is, the fact remains that condensed catalogues interspersed with a smattering of Trautwine and Molesworth are the only chemical engineering literature that exists, apart from scattered articles, most of which are very restricted in scope and aspect. Thus its bibliography reflects and confirms the heteroclitic nature of Physio-Chemical Engineering. The important influence which it does, and must, exercise on the technics of the future may result in its ultimately assuming a more definite and conventional position as a business or profession.

C. H. N.

Physostigmine (*Chem.*) *See* CALABAR BEAN.

Piacere, A (*Music*). At pleasure.

Piacevole (*Music*). Agreeably, pleasantly.

Pianette (*Music*). A small pianoforte.

Piangendo, Piangevole (*Music*). In a plaintive manner.

Pianissimo (*Music*). Very soft. Abbreviation, *ppp* (or *pp*).

Piano (*Music*). Soft. Abbreviation, *p*.

Pianoforte (*Music*). *See* MUSICAL INSTRUMENTS (STRINGED).

Piatti (*Music*). The Italian name for cymbals. *See under* MUSICAL INSTRUMENTS.

Piazza (*Architect.*) A rectangular open space surrounded by buildings or colonnades.

Pibroch (*Music*). The Scottish military music of the bagpipe.

Pica (*Typog.*) Type between English and small pica in size. The body of this type is generally used as the standard for leads, measures, etc. *See* TYPES.

Piccolo (*Music*). (1) *See* MUSICAL INSTRUMENTS (WIND). (2) An organ stop. *See* ORGAN, p. 441.

Picea (*Botany*). The genus of *Coniferæ* comprising the spruce fir (*P. excelsa*), yielding turpentine, resin, and timber, and the silver fir (*P. alba*).

Pick. A pickaxe, the familiar tool used in excavation, mining, etc.

—— *or* **Shoot** (*Textile Manufac.*) A throw of the shuttle carrying weft through the shed or opening between warp threads.

Picker *or* **Driver** (*Textile Manufac.*) A device fitted in shuttle box for propelling the shuttle.

Picker Leather. Leather specially tanned for the making of picker bends used in cotton spinning, etc.

Picking (*Weaving*). The second primary movement of the loom, *viz.* the propulsion of the shuttle across the loom sley and through the warp shed (*q.v.*) In the power loom this is generally effected by cam movement operating on picking arms or levers. There are two distinct methods: (1) Overpick; (2) Underpick. *See* LOOM.

Pickle. An acid solution used for cleansing the surface of metallic objects. *See* PICKLING.

Pickling (*Chem. Tech.*) Candle wicks are pickled to prevent them burning too fast, and also avoid their leaving too much ash. Borax, sal-ammonia, and phosphate of ammonia solutions are some of those employed. The wicks are steeped, wrung out, and dried. This treatment has done away with "snuffing."

—— (*Eng.*) Removing the hard skin on metal castings by immersion in dilute sulphuric or nitric acid; also used as a general term for processes in which an acid (or occasionally another liquid) is allowed to act on metals for the purpose of cleaning, etc.

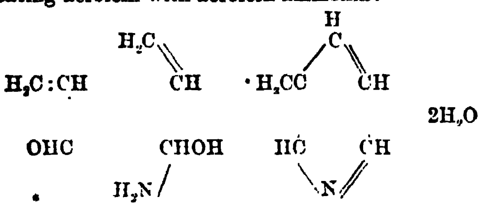
—— (*Leather Manufac.*) Sheep skins, after the wool has been removed, are pickled for export. The most common method in use is soaking the pelts in a weak solution of sulphuric acid, to which is added an excess of salt. Formic acid may be substituted for the sulphuric. *See also* CURING.

—— (*Met.*) The immersion of steel, etc., plates in dilute vitriol (*q.v.*) to remove scale and oxide prior to galvanising, or otherwise coating with a protective covering.

Picks (*Cotton Manufac.*) The term is applied to the weft threads in a cloth; sometimes termed SHOTS.

Picks (*Print.*) Blots or patches caused by dirty ink or pieces of paper or roller composition filling up the face of the letter. They are picked out with a needle or sharp pointed bodkin.

Picolines (*Chem.*) The monomethyl pyridines. *See* PYRIDINE. α-PICOLINE is a liquid; boils at 130°; on oxidation it yields picolinic acid. It is formed on heating the methyl iodide compound of pyridine in sealed tubes. It can be prepared from crude pyridine by dissolving in hydrochloric acid, and precipitating with mercuric chloride. The resulting double salt is decomposed by caustic soda. β-PICOLINE is a liquid; boils at 143°; on oxidation it gives nicotinic acid. It is obtained by heating acrolein with acrolein ammonia:

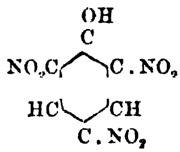


Also by heating glycerine with acetamide—

$$2CH_2OHCHOHCH_2OH + CH_3CONH_2 = C_5H_4CH_3N + CH_3COOH + 5H_2O$$

δ-PICOLINE is a liquid; boils at 144°; on oxidation it gives isonicotinic acid. It is formed along with the α-picoline when pyridine methiodide is heated in a sealed tube. It occurs in coal tar.

Picric Acid (*Chem.*) (Symmetrical trinitrophenol.)



Sometimes called carbazotic acid. Yellow crystalline solid; melts at 122°; sparingly soluble in cold water; fairly soluble in hot water. It is an acid, liberating carbon dioxide from sodium carbonate. Burns quietly on ignition; the fused acid explodes powerfully on detonation; it also explodes with great violence when heated with an oxidising agent such as red lead. It enters into the composition of a number of smokeless explosives, such as lyddite. It unites with many hydrocarbons directly, *e.g.* with anthracene and naphthalene, and the compounds so formed are useful in identifying hydrocarbons. With phosphorous pentachloride it forms picrylchloride, $C_6H_2(NO_2)_3Cl$. It is extensively used as a dye; it dyes unmordanted wool and silk a greenish yellow colour. Picric acid is formed by the action of nitric acid on many organic substances—*e.g.* resins, leather, wool, silk. It is prepared by dissolving phenol in strong sulphuric acid, and acting on the mixture of ortho- and para-phenol sulphonic acids so formed with strong nitric acid. *See also* DYES AND DYEING *and* EXPLOSIVES.

Picrotoxin (*Chem.*) The active principle of the Indian Berry (*Cocculus indicus*). Silky crystals; melts at 192° to 200° with change; sparingly soluble in cold water; fairly soluble in hot water; readily soluble in alcohol. Lævorotatory; dissolves in strong sulphuric acid with golden yellow colour; reduces Fehling's solution. It is poisonous; its solutions have a bitter taste. It appears to be a mixture of two substances, *viz.* Picrotoxinine, $C_{15}H_{16}O_6$, and Picroline, $C_{15}H_{18}O_7$.

Pie (*Typog.*) Unsorted or "broken" type indiscriminately mixed.

Piece Mould. *See* CAST (*Sculp.*)

Piecework. A system by which workmen are paid for their labour at so much for each job or piece of work, instead of being employed at a fixed rate per hour.

Pieno (*Music*). Full.

Pier (*Build.*) (1) A pillar of brick or stone. (2) The part of a wall which is made thicker, forming a vertical projection. (3) The solid parts between openings in a wall, *e.g.* where a window or door intervenes. (4) The support to which a gate is hung. *See also* ARCH.

—— (*Civil Eng.*) A breakwater or jetty built out into the sea, serving to form a harbour, a landing place, or a marine promenade.

Piezometer (*Phys.*) An instrument for experiments on the elasticity of liquids; the latter are subjected to an increase of pressure, and the resulting diminution of volume observed.

Pig (*Glass Manufac.*) An iron grooved support for the blowing or working rods. It is placed immediately in front of the mouth of the Pot, and upon the Pat.

—— (*Met.*) The bars in which various metals are cast at the conclusion of the processes of smelting. Iron is always cast in pigs weighing about a hundredweight, when it is run out of the blast furnace.

Pig Bed (*Met.*) A layer of sand in front of a blast furnace, in which open moulds are made for casting the pigs. The main channel along which the molten metal runs from the furnace is termed the Sow.

Pig Boiling (*Met.*) A method of puddling iron (*q.v.*), in which basic oxidisers are added to the metal in the furnace to remove the carbon, etc., as opposed to "dry puddling," in which oxidation is effected solely by the air in the gases, to which the metal is subjected in the reverberatory furnace.

Pigeon Holes (*Typog.*) Wide spaces between words are derisively called pigeon holes, it being the duty of a compositor to avoid them when possible.

Pig Iron (*Met.*) Iron as it comes from the smelters. It is roughly classified according to its suitability for conversion into wrought iron, steel, castings, etc. *See also* IRON.

Pigments (*Dec.*) The class of bodies, either white or coloured, which, when reduced to a fine powder and mixed with oil, japan, water, or other vehicle, form a paint (*q.v.*) Pigments are both of mineral and organic origin, white lead and ochre being examples of the former, and ivory black and gamboge of the latter. A classification of pigments may be made either according to their colour, chemical character, or their lasting properties when exposed to light and air or to the action of lime. The following lists are arranged on the last mentioned plan: Pigments which are accepted as PERMANENT: Colcothar, Indian Red, Light Red, Red Ochre, Red Oxide, Rouge, Scarlet Red, Venetian Red, Vermilion

(doubtful), Cobalt Blue, Prussian Blue, Ultramarine, Cadmium Yellow, Sienna, Yellow Ochre, Chrome Green, Cobalt Green, Terra Verte, Umber, Vandyke Brown, Lampblack, Ivory Black, Carbon Black, Barytes (Sulphate of Barium), Blanc Fixe, Charlton White, China Clay, Gypsum Lithopone, Orr's White, Satin White, Strotian White, Whiting, and Zinc Oxide. NOT PERMANENT, *i.e.* pigments more or less affected by exposure to light or sulphuretted hydrogen: Carmine, Cochineal Lake, Crimson Lake, Derby Red, Orange Red, Red Lead, Royal Red, Scarlet Lake, Signal Red, Vermilionette, Mineral Blue, Chrome Yellow, Naples Yellow, Chrome Red, Emerald Green, Green Lake, Scheele's Green, Verdigris, Sulphate of Lead, and White Lead. As a constituent of paint a pigment plays an important part. It gives solidity and strength to the film of oil, and increases its thickness; hence forms a better protection to the surface to which it is applied. It also renders the film less porous. Of white pigments which form the base of most paints the chief virtue is opacity or body (*q.v.*) It is principally because white lead possesses this quality in so eminent a degree that it is so largely used as a paint. Some pigments, such as barytes, are very deficient in this quality, but being quite inert and very durable they make good paints when mixed in small proportions with white lead.

Pigskin (*Bind.*) The tanned hide of the domestic swine. Much used for binding in the Middle Ages. Dr. Dibdin stigmatises pigskin in book binding as "the eternal engenderer of mould and mildew." It has again come into use for books that are much handled, *e.g.* for the backs of books in public lending libraries.

Pigtail Twist. A laboratory appliance for quickening the filtration of liquids where a vacuum pump is not available. It is a piece of glass tubing the same diameter as the stem of the filter funnel, with a single coil near one end. The shorter length is coupled to the funnel by indiarubber tubing. The weight of liquid in longer limb creates a "pull" on the contents of the funnel.

Pilaster (*Architect.*) A column attached to a wall from which it projects one-sixth to one-fourth of its width. The anta or pilaster used in Greek work was always treated quite differently from the detached columns, but in Roman and Renaissance work the details of the pilaster-capital and base are the same as those of the columns. The term pilaster is occasionally used to denote a detached square column. A pilaster is also known as a parastata. *See* PILASTER STRIPS.

Pilaster Strips (*Architect.*) Vertical strips of ashlar in the rubble walling of Anglo-Saxon work. *See* ANGLO-SAXON ARCHITECTURE.

Pile (*Civil Eng., etc.*) A heavy piece of timber of square section, pointed and shod at the end, driven into soft or wet ground to form foundation for masonry or part of a wall, as in the case of a cofferdam, etc.

—— (*Elect.*) (1) A primitive form of battery, due to Volta, consisting of a series of alternate discs of copper and zinc, separated by discs of cloth damped with dilute acid. (2) A THERMOPILE (*q.v.*)

—— (*Her.*) One of the ordinaries, in the form of a long thin wedge with the point downwards.

Pile (*Met.*) A number of bars of puddled iron (*q.v.*) arranged one on top of each other ready to be heated and welded together; the mass thus formed is again rolled out into bars, which are much stronger than the original bar, as the grain or fibre of the iron can be caused to run in different directions, according to the method in which the bars are piled.

—— (*Textile Manufac.*) The fibre on the surface of cloth. It may be obtained by raising, in cloths which have been felted; or developed in weaving by using wires over which the warp threads are passed and cut; or left in loops, as in Axminster and Brussels carpets, respectively.

Pile Cap (*Civil Eng.*) A horizontal beam connecting the heads of adjoining piles.

Pile Driver (*Civil Eng.*) Mechanism for driving piles into the ground. It consists essentially of a heavy weight, termed a MONKEY, which is allowed to fall from a considerable height on to the head of the pile. It is guided in its fall by two uprights, forming part of the frame of the pile driver. The weight is raised either by hand or by power.

Pile Hoop (*Civil Eng.*) A hoop or band of iron, fixed on the upper end or head of a wooden pile to prevent the timber from splitting under the blows of the falling weight or monkey of the pile driver.

Pile Screw (*Civil Eng.*) The screw at the end of a SCREW PILE (*q.v.*)

Pile Shoe (*Civil Eng.*) An iron point fixed to the end of wooden piles to enable them to enter the ground.

Piling (*Met.*) The arrangement of bars and slabs of malleable iron or steel to form bundles or "piles," which are reheated and welded into a solid mass from which sheets, rails, and merchantable iron are rolled. Experience and skill are needed in the selection of metal and method of piling for various purposes.

Pillar (*Architect.*) A disengaged column used to support an arch. Its proportions always differ from those of the orders when used in Roman or Renaissance architecture. *See* CLUSTERED PILLAR.

—— (*Mining*). A column or mass of ore or rock left *in situ* in order to support the roof of the working.

Pillar and Stall System (*Mining*). *See* MINING.

Pillar Drill (*Eng.*) A drilling machine carried by a vertical central column or pillar.

Pillar File (*Eng.*) A thin narrow file, usually with a SAFE EDGE (*q.v.*)

Pillow Block (*Eng.*) A PLUMMER BLOCK (*q.v.*)

Pilot Engine (*Civil Eng.*) An engine run in front of a train to ascertain that the line is clear, signals in working order, etc.

Pilot Lamp (*Elect. Eng*). An incandescent lamp which is used to indicate roughly when the voltage of a dynamo, storage battery, etc., has its proper value.

Pilot Wires (*Elect. Eng.*) Wires leading from a particular point in a circuit to enable tests of the voltage, etc., at the point to be made at a testing station.

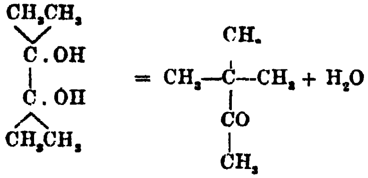
Pily *and* **Pily Bendy** (*Her.*) A shield divided pile wise, also with piles and bends; the latter term is then used. *See* PILE *and* HERALDRY.

Pin (*Carp. & Join.*) (1) A piece that fits into the socket of a dovetail. (2) A short wooden rod of small diameter, used in a variety of ways.

—— (*Eng.*) A general term for a small cylindrical piece of metal, especially one forming the fulcrum of a lever, or small fixed axle for a wheel or pulley.

Pinacoid (*Min.*) A crystal form which lies parallel to two of the axes of the crystal.

Pinacoline (*Chem.*) $CH_3.CC.C(CH_3)_3$. A colourless liquid; boils at 106°; smells like peppermint. On reduction it forms pinacolyl alcohol, $CH_3CHOH.C(CH_3)_3$, which is a liquid smelling like camphor; on oxidation it gives trimethylacetic acid, $(CH_3)_3C.COOH$. It is formed when pinacone is heated with dilute sulphuric acid—



Pinacone (*Chem.*)

$$\begin{array}{l}(CH_3)_2C.OH \\ \quad\;\; | \\ (CH_3)_2C.OH\end{array} \qquad \text{(Tetramethylglycol.)}$$

White crystalline solid; melts at 38°; boils at 172°; soluble in alcohol and in ether; dissolves in boiling water, and crystallises with $6H_2O$; the crystals melt at 42°. Heated with dilute sulphuric acid it loses one molecular proportion of water, and undergoes a remarkable intramolecular change to Pinacoline (*q.v.*) Pinacone is obtained by the reduction of acetone with sodium. *See* KETONES. Pinacone is the simplest member of a whole series of tetra-alkyl glycols, which are called by the general name Pinacones.

Pinacotheca. A picture gallery.

Pincers. In carpentry a tool provided with jaws for gripping the head of a nail which it is desired to withdraw from wood. Also applied in other trades to tools, constructed on a similar principle, used for gripping different objects.

Pinch Bar (*Eng.*) A crow bar.

Pinchbeck. An alloy of copper, zinc, and tin, something like gold in appearance. Formerly used in the manufacture of cheap jewellery. Named after the inventor, Christopher Pinchbeck.

Pinched Post (*Paper*). A sheet of drawing or writing paper measuring 18½ by 14¾ inches.

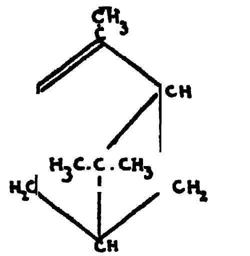
Pin Cop (*Cotton Spinning*). *See* COP.

Pin Drill (*Eng, etc.*) A drill or bit having a small cylindrical projection in the centre of its cutting end, which serves as a guide when a small hole (into which the pin fits) is being drilled out to a larger size.

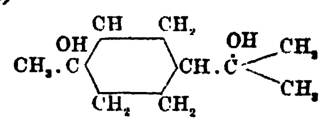
Pine. *See* WOODS.

Pineapple (*Botany*). The well known fruit of the tropical plant *Ananas sativus* (order, *Bromeliaceæ*) consists of a succulent mass formed by the coalescence of the fruits of a mass of flowers.

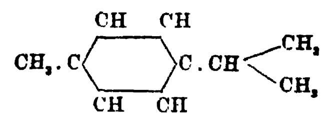
Pinene (*Chem.*) (A Terpene.)



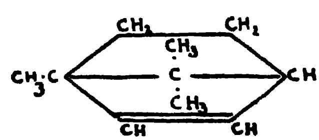
A colourless liquid; boils at 155°; volatile in steam; smells like turpentine; it is known in a dextrorotatory (45°), a lævorotatory, and an optically inactive form; insoluble in water; soluble in ordinary organic solvents. It has a very large number of reactions which are important in the chemistry of the terpenes (*q.v.*) A few are: (1) It adds one molecular proportion of bromine, forming a *dibromide*; it adds a like amount of hydrogen chloride, forming a *hydrochloride* (artificial camphor); it adds a like amount of nitrosyl chloride, forming *pinene nitrosochloride*; it adds twice the amount of hypochlorous acid, forming a dichlorhydrin with splitting of the bridged ring; it adds two molecules of water under the influence of dilute sulphuric or nitric acids, forming *terpin hydrate*, which has been synthesised and shown to have the constitution (*see* TERPENES)



When the dibromide is heated, it gives cymene; pinene itself on heating with iodine also gives cymene—

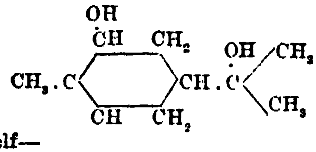


When the hydrochloride is heated with sodium acetate and acetic acid at 200°, it does not yield pinene again, but an isomeric terpene called camphene.

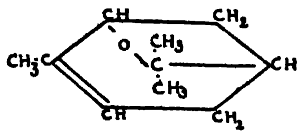


The hydrochloride from dextropinene is inactive; that from lævopinene is lævorotatory. The nitrosochloride, on heating with alcoholic potash, loses hydrochloric acid and forms nitrosopinene, which can be reduced to an amine, and the pinylamine hydrochloride on heating gives a good yield of cymene. The nitrosochloride is important as a means of identifying pinene; for this purpose it is prepared by acting on the pinene with glacial acetic acid, ethyl nitrite, and hydrochloric acid in the cold: the nitrosochloride crystallises out. (2) A very large amount of work has been done on the oxidation

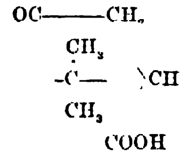
products of pinene. It is oxidised in air under the influence of sunlight to pinol hydrate.



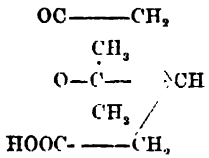
Pinol itself—



is always formed in small quantity in addition to the nitrosochloride, when nitrosylchloride acts upon pinene. When pinene is oxidised with nitric acid it yields terephthalic acid (*q.v.*) and terebic acid—



The same acid is formed when pinol is oxidised with nitric acid or with permanganate. When pinene is oxidised with chromic acid it yields terpenylic acid:



The same acid is formed when pinol hydrate is oxidised with potassium permanganate. Both terebic and terpenylic acids have been synthesised. It will be seen that every reaction is in harmony with the formula given for pinene, so that although pinene has not been synthesised its formula may be regarded as established. Pinene is the principal constituent of turpentine, and the dextropinene occurs in American and Burmese turpentine, and the lævopinene in French turpentine. Pinene also occurs in many other essential oils, *e.g.* those of rosemary, pine, juniper, camphor, laurel, lavender, mace, parsley, sage, etc It can be obtained from terpentine by distillation.

Pinholing (*Dec.*) This defect in varnished work is only found on the best class of work, which has been rubbed down with felt and powdered pumice-stone, and is due to the ground pumice not having been properly washed off.

Pinion (*Eng., etc.*) A small toothed wheel. The term does not denote any particular size or form of wheel.

Pin Mark (*Typog.*) A small circular indentation on the side of a type, made in the process of casting by a small pin in the mould. *See* TYPEFOUNDING.

Pinnacle (*Architect.*) A feature which frequently forms the termination of a buttress in Gothic architecture. It was used with the object of adding weight to the buttress, thus assisting the latter in resisting thrusts. It generally consists of a shaft terminating in a small spire. *See* FLYING BUTTRESS.

Pinny (*Met.*) Metal containing spicules or small fragments of metal, harder than the rest, is said to be "pinny."

Pint. *See* WEIGHTS AND MEASURES.

Pinus (*Botany*). A large and important genus of *Coniferæ*, yielding timber, resin, turpentine, tar, and other products.

Pinxit. This Latin word, or the abbreviation *pinx.*, following the name of an individual on a painting or engraving, indicates that such person is the painter. The Latin word *sculpsit*, or the abbreviation *sculp.*, indicates the engraver.

Pipe Bending (*Eng., etc.*) In bending pipes of soft or malleable metal the cavity is first filled with sand, resin, fusible metal, etc., or by driving a bobbin or follower into the bore; the pipe is then bent by hammering or by the direct application of force in some convenient way. The material in the bore prevents a collapse of the pipe at the bend; it is removed when the bending is completed.

Pipeclay. Kaolin or china clay (*q.v.*). It is used in forming both moulds and patterns in some kinds of castings, and for very many economic purposes, *e.g.* cleaning or whitening soldiers' belts, gloves, etc.

Pipe Cutter (*Eng., etc.*) A tool consisting of a bar bent into a hook which grasps the pipe, and a sharp-edged disc of hardened steel which travels round the outside of the pipe. By applying considerable pressure this steel disc cuts into the metal.

Pipe Moulding. Cast iron pipes are usually made in considerable quantities at a time; the smaller sizes are moulded from an iron pattern, the larger ones are struck (*q.v.*) The mould is commonly vertical.

Pipe, Organ. *See* MUSICAL INSTRUMENTS.

Pipe Ovens *or* **Stoves** (*Met.*) A series of pipes enclosed in a chamber or oven heated by a fire or by furnace gases; air is driven through the pipes to become heated before being supplied to a blast furnace worked with a hot blast.

Piperaceæ (*Botany*). A lowly order of Dicotyledons of economic interest, as the genus *Piper* supplies the condiment pepper and Cubebs and Matico. The Betel leaf used in Areca nut chewing is derived from *Piper betle*.

Piperazine (*Chem.*) $NH\left<\begin{matrix}CH_2-CH_2\\CH_2-CH_2\end{matrix}\right>NH$

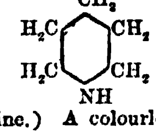
White crystalline solid (tables); melts at 104°; boils at 145°; soluble in water; its solution is a good solvent for uric acid, and is used in medicine, but its value is doubtful; powerful alkali; obtained by heating ethylene diamine hydrochloride, or by heating aniline with ethylene dibromide, forming the nitroso-compound of the product of this reaction, and boiling the nitroso-compound with alcoholic potash—

$$2C_6H_5NH_2 + 2C_2H_4Br_2 = C_6H_5N\left<\begin{matrix}CH_2.CH_2\\CH_2.CH_2\end{matrix}\right>NC_6H_5 +$$

$$4HBr \rightarrow ON.C_6H_4N\left<\begin{matrix}CH_2.CH_2\\CH_2.CH_2\end{matrix}\right>N.C_6H_4NO \rightarrow$$

$$HN\left<\begin{matrix}CH_2.CH_2\\CH_2.CH_2\end{matrix}\right>NH$$

Piperidine (*Chem.*)



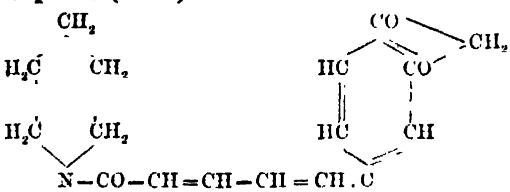
(Hexahydropyridine.) A colourless liquid; boils at

106°; smells like ammonia and pepper; soluble in water; powerful base, forming salts; it is a secondary base, for it yields a nitroso-compound with nitrous acid, and gives methyl piperidine with methyl iodide. Not attacked by boiling concentrated nitric acid; heated with concentrated sulphuric acid, it yields pyridine. It is prepared from piperine (*q.v.*) by boiling with alcoholic potash; also from pyridine by reduction with alcohol and sodium amalgam; also by heating pentamethylenediamine (*see* CADAVERINE) hydrochloride

$$CH_2 \begin{matrix} \diagup CH_2 - CH_2NH_2HCl \\ \diagdown CH_2 - CH_2NH_2HCl \end{matrix} =$$

$$CH_2 \begin{matrix} \diagup CH_2 - CH_2 \diagdown \\ \diagdown CH_2 - CH_2 \diagup \end{matrix} NH . HCl + NH_4Cl$$

Piperine (*Chem.*)



(an alkaloid). A white crystalline solid (prisms); melts at 129°; insoluble in water, soluble in alcohol and ether; it is a very weak base; with concentrated sulphuric acid it gives a blood-red coloration which vanishes on addition of water (test). Boiled for twenty-four hours with alcoholic potash, it is resolved into piperidine (*q.v.*), which can be distilled off, and piperic acid. Piperine can be reproduced from these by making the chloride of piperic acid and allowing this to act on piperidine in solution in benzene. When piperic acid is oxidised it yields piperonal (*q.v.*), and the acid can be synthesised from piperonal thus: Piperonal is carefully heated with aldehyde and dilute caustic soda—

$$C_6H_3 \begin{matrix} \diagup O_2CH_2 \\ \diagdown C \overset{\diagup H}{\underset{\diagdown O}{}} \end{matrix} + CH_3 . CHO =$$

$$C_6H_3 \begin{matrix} \diagup O_2CH_2 \\ \diagdown CH : CH . CHO \end{matrix} + H_2O$$

Piperonyl Acrolein.

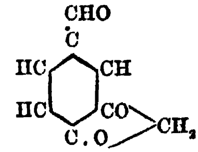
This aldehyde undergoes Perkin's reaction (*q.v.*) with acetic anhydride and sodium acetate—

$$C_6H_3 \begin{matrix} \diagup O_2CH_2 \\ \diagdown CH : CH . CHO \end{matrix} + CH_3COOH =$$

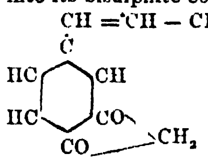
$$C_6H_3 \begin{matrix} \diagup O_2CH_2 \\ \diagdown CH : CH - CH : CH - COOH \end{matrix} + H_2O.$$

The product is piperic acid. Thus piperine is an alkaloid which can be completely synthesised. Piperine occurs in black pepper, white pepper, long pepper to the extent of 8 to 9 per cent. It is obtained from the ground white pepper by mixing it with slaked lime and water, boiling for 15 minutes, and evaporating to dryness on the water bath. The dry powder is extracted with ether, and the crude alkaloid crystallises out on concentrating the ethereal solution. It is recrystallised from alcohol till pure.

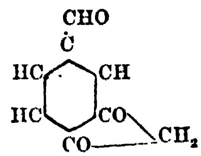
Piperonal (*Chem.*)



(Protocatechuicaldehyde methylene ether). Also called Heliotropine, because it smells like heliotrope. A white crystalline solid (prisms); melts at 37°; soluble in alcohol, ether, hot water. Its chemical behaviour is that of an aldehyde, *e.g.* it gives piperonylic acid, $CH_2O_2C_6H_3COOH$, on oxidation; piperonyl alcohol, $CH_2O_2C_6H_3CH_2OH$, among other products, on reduction; and it yields an oxime which melts at 110°. It is formed from protocatechuic aldehyde and methylene iodide by the action of an alkali: it is also formed by the oxidation of piperic acid (*see* PIPERINE) by potassium permanganate. In quantity for use as a perfume it is prepared from isosafrol. *See* SAFROL. The isosafrol is oxidised by potassium dichromate and dilute sulphuric acid, the product distilled in steam, the distillate extracted with ether, and the piperonal purified by conversion into its bisulphite compound.



Isosafrol.



Piperonal.

Pipe Sleekers (*Moulding*). Tools used in smoothing the interior of moulds for pipes, etc.

Pipe Tap (*Eng., etc.*) A screw tap (*q.v.*) for cutting gas threads; often termed a GAS TAP.

Pipe Tongs (*Eng., etc.*) Tongs with jaws adapted to holding and screwing up wrought iron pipe or barrel. The inner surface of the jaws is curved to fit the pipe, and furnished with grooves or serrations to secure a firm grip.

Piqué (*Textile Manufac.*) A cloth with ribs or welts running from selvedge to selvedge, produced by the insertion of thick weft or wadding between a fine face cloth and the back warp.

Pirameter. An instrument for measuring the amount of draught resistance of a road to a vehicle.

Pirl Finish (*Woollen and Worsted Manufac.*) A style of finish applied to fine cloths of a Venetian type in which clearness and brightness are the chief characteristics.

Pirn (*Cotton Manufac.*) A bobbin, tube, or quill used for winding weft yarn on to, so as to fit into the shuttle.

—— *or* **Quill** (*Silk Manufac.*) A hollow bobbin carried in shuttle on which the weft is wound.

Piscina (*Architect.*) A shallow basin placed in a niche near the altar in a church. A pipe is carried from the basin to the exterior of the building, the piscina being intended to receive the water used by the priest for washing his hands and rinsing the chalice used in the Communion Service.

Pisolite (*Geol.*) A coarse variety of oolite (*q.v.*) with the separate grains, in many cases, as large as peas. Like normal oolite, this type seems to be, in nearly all cases, due to deposition around a nucleus of successive layers of carbonate of lime secreted and left by an alga.

Piston (*Eng.*) In general a movable partition fitting closely into the bore of a hollow cylinder. The piston of a steam engine is a disc, firmly attached to the piston rod, and provided with grooves on its circumference into which are fitted piston rings (*q.v.*) or some other form of steam-tight packing. In gas and petrol engines the piston is usually a tubular casting closed at one end, and the connecting rod is attached to the piston without any intermediate piston rod. *See* GAS ENGINE, *etc.*

—— (*Music*). A valve used in brass instruments, enabling the tube to be lengthened, and lowering the pitch of the sound. *See* VALVE HORN, p. 435.

Piston Packing (*Eng.*) The material placed round a piston to make a steam-tight or an air-tight fit.

Piston Ring (*Eng.*) One of the metal rings fitted on a piston to make it steam tight. They are turned to a diameter slightly larger than that of the cylinder, and are then cut across and opened out sufficiently to enable them to be passed over the piston till they fall into one of the grooves cut on the periphery of the piston. When the piston is put in place the rings press closely against the bore of the cylinder. The joints or cuts in the rings should be arranged so that they do not come opposite to each other, in order that the possibility of leakage may be reduced to a minimum.

Piston Rod (*Eng.*) The cylindrical rod which communicates the motion of the piston to the connecting rod.

Piston Rod Gland (*Eng.*) The short tube which fits into the stuffing box (*q.v.*) in the cylinder cover, and presses the packing against the piston rod in order to make a steam-tight joint.

Piston Spring (*Eng.*) A piston ring (*q.v.*), or in some cases a steel spring placed in the groove round the piston to press the ring outward against the cylinder.

Piston Valve (*Eng.*) A valve consisting of a small piston and cylinder; in the side of the latter are the openings, which are opened and closed by the movement of the piston past them. Piston valves are occasionally used in steam engines instead of the ordinary Slide Valve (*q.v.*)

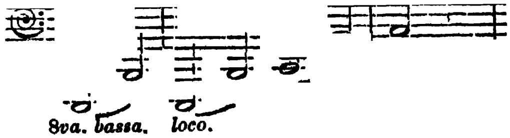
Pitch. The solid hydrocarbon residue left after the final distillation of certain organic substances, *e.g.* coal tar. It is used for caulking joints, etc., and occasionally as fuel. *See* GAS MANUFACTURE, PATENT FUEL, PETROLEUM, RESINS, *etc.*

——, **Burgundy** (*Botany*). A resinous exudation from the stem of the spruce fir, *Picea excelsa* (order, *Coniferæ*). The chief supply comes from Austria, Baden, and Switzerland. It resembles colophony, and is used medicinally for making plasters.

——, **Coal Tar** (*Dec.*) This is sometimes used instead of Volges pitch as a substitute for natural asphaltum. It is obtained by distillation of coal tar, and is of two kinds—soft pitch and hard pitch. The latter is too brittle for ordinary use. Soft pitch is thinned down with naphtha for varnish makers' use. It is also used to mix with coal dust to make briquettes.

Pitch (*Build., Eng., etc.*) (1) The angle of inclination of a roof, a flight of stairs, etc. (2) The distance between the centres of a number of holes, bolts, rivets, etc. (3) The distance a screw-thread advances in a single turn, measured along a line parallel to the axis. (4) The distance between the centres of wheel teeth, measured on the pitch-line.

Pitch (*Music*). The acuteness or gravity of a sound, determined by the rapidity with which the vibrations follow one another. The nomenclature of the different octave pitches is



CCC to BBB. Triple Great or 32 ft. 8ve. *CCCC to BBBB.*	CC to BB. Double Great or 16 ft. 8ve. *CCC to BBB.*	C to B. Great or 8 ft. 8ve. *CC to BB.*	c to b. Small or 4 ft. 8ve. *C to B.*

c^1 to b^1 once marked or 2 ft. 8ve. *c to b.*	c^2 to b^2 twice marked or 1 ft. 8ve. *c^1 to b^1.*	c^3 to b^3 thrice marked or 6 in. 8ve. *c^2 to b^2.*	c^4 to b^4 four times marked or 3 in. 8ve. *c^3 to b^3.*

In organ nomenclature, however, it is usual to talk of these octaves differently, as shown in the lower line of italics above. The standard of pitch in England unfortunately varies considerably. The two recognised pitches in use at the present time (1905) are the following: (1) The Old Philharmonic or high concert pitch, A,  = 455, and C,  540 double vibrations per second at 68° Fahrenheit. This pitch was introduced into England at the old Italian Opera, and adopted as the Kneller Hall or military pitch. Feeling is strongly against this extremely high pitch, which is 34 double vibrations per second more for A than in Handel's time; but unfortunately, partly because of the expense of providing new instruments for the bands, and partly because of an idea that more brilliancy is obtained with a high pitch, the retention of this high pitch is persisted in by military bands. (2) The other recognised pitch is the New Philharmonic, or Diapason Normal, A = 439 and C = 522 double vibrations per second. This pitch has been adopted not only by the Philharmonic Society, but also by the Royal Academy of Music, the Royal College of Music, the Guildhall School of Music, the Queen's Hall Orchestra, the Italian Opera, etc. The orchestral instruments are tuned to the French diapason normal A = 435, it being found that as soon as the instruments warm up the pitch rises four vibrations to A = 439; therefore, to meet this natural sharpening, the organ and pianoforte (the steel strings of this latter instrument having so great a tension—*see* PIANOFORTE, p. 430—are unaffected by the temperature of the building during a concert) are tuned to A = 439, as otherwise these instruments would soon be out of tune with the orchestra. Besides these two recognised pitches, there is the Medium, A = 446, and C = 530. In

England pianoforte tuning is done from a C tuning fork, the A tuning fork being more useful for orchestral and other stringed instruments.—W. W.

Pitch (*Typog.*) A line, imaginary or real, drawn across the coffin or bed of a printing machine to indicate the place at which contact is first made when the forme passes beneath the cylinder. The distance from the edge of the bed may be measured by a gauge.

Pitchblende (*Min.*) A complex uranate of uranyl, lead, and other metals, usually thorium, often metals of the lanthanum and yttrium groups, and containing traces of radium. Cubic, the crystallised varieties being known as Uranniobite, Bröggerite, Cleveite, and Nivenite. The crystallised varieties are rare. The commoner massive variety is of a dull grey black colour, and has a peculiar pitchlike lustre. Its density is high—the massive variety about 6·4 and the crystallised variety as high as 9·7. It contains 70 to 80 per cent. of the oxides of uranium, with about 10 per cent. of lead, 5 per cent. silica, and 3 per cent. ferrous oxide, besides traces of many other elements. Also known as Uraninite. It is found in several mines in Cornwall; abroad at Kongsberg in Norway, Marienburg, Schneeberg, Johanngeorgenstadt, and Wiesenthal in Saxony, Joachimstal and Przibram in Bohemia, Retzbanya in Hungary, Adrianople in Turkey, Middletown and Haddam in Connecticut, etc. In Bohemia uranate of sodium is made from it. The oxide of uranium prepared from it is used to give the well known opalescent green colour to glass. As a porcelain pigment the oxide gives a yellow tint in the enamelling furnace and a black colour in the baking furnace. The mineral is now of great interest as the chief source of radium.

Pitchboard (*Carp. and Join.*) A triangular shaped piece of board, used for setting out stairs.

Pitch Chain (*Eng.*) A metal chain, such as that used in cycles for transmitting motion from one toothed wheel to another.

Pitch Circle (*Eng.*) Two ordinary toothed wheels gearing with one another may be replaced in theory by two circles rolling in contact, termed the Pitch Circles; the ratio of the diameters of these two circles is inversely as the angular velocities of the two gear wheels. *See also* WHEEL TEETH.

Pitch Cone (*Eng.*) A pair of bevel wheels can be replaced in theory by a pair of cones rolling in contact with each other, the axes of the cones intersecting and coinciding with the axes of the bevel wheels. These cones are the pitch cones of the two wheels.

Pitcher. A granite set. A small paving stone.

Pitching Pieces (*Build.*) The carriage pieces supporting winding stairs.

Pitch Line (*Eng.*) In the case of a toothed rack, the pitch circle (*q.v.*) becomes a straight line, which may be termed the PITCH LINE. The name is, however, often used for the pitch circle of an ordinary wheel.

Pitch of Chains (*Cycles, etc.*) The distance between the centres of two successive pins in a chain.

Pitch of Poles, Windings, etc. (*Elect. Eng.*) The distance between the centres of poles, armature conductors, etc., measured along the pitch line.

Pitch of Wheels (*Eng.*) The distance from the centre of one tooth to the centre of the next.

Pitchpipe (*Music*). A small reed pipe made of metal which sounds the different notes of the scale when the wind is drawn through by the mouth, according to the length of the vibrating portion. The lengths are marked off at the end. It is known as Eardley's chromatic pitchpipe.

Pitchstone (*Geol.*) An eruptive rock with a resinous fracture and lustre, usually of sub-acid or even of sub-basic composition, which has cooled from the molten state under but little pressure and at a comparatively rapid rate. Hence it has passed direct into a sub-vitreous state. Most, if not all, pitchstones occur as Trappean rocks. One of the best known examples is the Pitchstone of Corriegills, Arran, in which the microscope reveals structures of great interest. Another forms the Scuir of Eigg, which may also be intrusive.

Pit Head Gear (*Mining*). The supports of the winding gear (*q.v.*) over the mouth of a shaft.

Pitman (*Eng.*) A CONNECTING ROD (*q.v.*)

Pit Sand (*Build.*) Sand that is dug out of a pit, as distinguished from sea and river sand.

Pit Saw (*Carp., etc.*) A long saw worked by two men, one standing above the wood, the other below, in a pit, termed a SAW PIT. The pit saw is now superseded by saws worked by power.

Pitting (*Dec.*) A defect in varnish which on drying shows small holes over its surface. It is caused by a greasy, damp, or oily surface, or it is caused by applying an elastic varnish over a hard and unyielding ground. Resin varnishes of low grade not infrequently exhibit this defect.

—— (*Eng.*) A common form of corrosion in boilers. It is not peculiar to any special part, except in locomotives, where the largest ring and bottom of the barrel suffer most. Feed water heaters suffer chiefly at the cold water inlet. It takes the form of cones or spherical depressions filled with a yellowish, dusty deposit, consisting mainly of ferric oxide and some organic matter, with mineral salts. The powder forms a blister above the pit, having a thin skin. The skin is chiefly calcium carbonate, ferrous oxide, gypsum, and magnesium carbonate. Bad circulation, very soft, lime free water, and condensation in the upper part of the steam space, when one boiler in a battery is kept standing for long, seem to be the chief causes.

Piu (*Music*). More; as *piu mosso*, more movement, quicker. *Piu forte*, louder: abb. *p.f.*

Pivot. A point, centre, or fulcrum, on which a related part turns or oscillates.

—— (*Clocks and Watches*). The reduced cylindrical end of a small shaft or "arbor": the part that works in the bearing.

Pizzicato (*Music*). A direction used in stringed instrument music to denote that the strings are to be plucked with the finger instead of being bowed.

Place Bricks (*Build.*) Underburnt, soft bricks, only used for inside walls that have to be plastered.

Placer (*Mining*). (1) Gold diggings in general, *i.e.* where surface deposits are washed for gold, etc. (2) Mining by means of a jet of water under pressure

(hydraulic mining), by which loose earth, etc., is washed away, is often termed Placer Mining.

Placer (*Pottery*). A person whose duty it is to place the various wares in their right positions in their respective ovens.

Plagal (*Music*). *See* MODES.

Plagal Cadence (*Music*). *See* CADENCE.

Plagioclase (*Geol.*) A convenient general term employed for all the felspars except Orthoclase, as all but this one cleave at such angles that no two of the adjacent cleavage faces are at right angles to each other. The two chief Plagioclase felspars are the Soda felspar Albite and the Lime felspar Anorthite. Native mixtures of these, in various proportions, constitute a number of intermediate types, of which the Soda Lime felspar Oligoclase and the Lime Soda felspar Labradorite are geologically the most important.

Plain (*Lace Manufac.*) Yarn that has not been "gassed."

Plain Song (*Music*). It is the special music used officially in the Church services, and is so called to distinguish it from measured and figured music. The music is written on four-lined staves with either the (F) or (C) clefs placed on the most convenient line according to the compass of the melody, which usually does not exceed an octave. The notation consists of three shapes, the , the , and the . These have always been known as the long, the breve, and the semibreve; but the investigations of the Solesmes Fathers show that these different shapes are the result of different plain song writing, and do not express difference of time value. It is shown that diamond shaped notes occur in well written manuscripts in descending passages only, and Spanish manuscripts have diamond shaped notes instead of square ones throughout, whilst a tail is added to every *single* note. These notes are used in combination to form certain figures called neums. The plain song melodies are formed from certain scales called modes (*q.v.*), the only accidental allowed being the B flat, and this in order to avoid the interval of the tritone. *See also* MODES *and* NOTES.

Plain Tile (*Build.*) A flat roofing tile, with or without nibs at the back for fixing.

Plain Weave (*Cotton Manufac.*) *See under* LOOM (figs. 2 and 3).

Plan. (1) The view of an object as seen from above. (2) Commonly used for a SECTIONAL PLAN; that is, the intersection of any object, *e.g.* a building with a horizontal plane. If this plane coincide with the level of ground, we get a GROUND PLAN; but drawings showing the outline of different floors are also termed plans.

Planchet (*Coins*). A flat smooth strip of metal from which coins are struck.

Plane. A flat surface, *i.e.* one in which a straight line lying entirely in the surface may be drawn in any direction. The last condition should be noted, for straight lines may be drawn on the surfaces of cylinders, cones, etc., but they cannot be drawn in any direction.

—— *See* WOODS.

Plane, Plane Iron (*Carp.*) *See* PLANES.

Plane of the Ecliptic (*Astron.*) The plane in which the Earth moves round the sun.

Plane of Twinning (*Min.*) *See* TWIN PLANE.

Planer (*Typog.*) A rectangular flat piece of wood with a smooth surface, and generally grooved on the longer edges. Used in conjunction with the mallet for levelling type before it is locked up in the chase.

—— (*Eng.*) *See* PLANING MACHINE.

Planes (*Carp. and Join.*) Planes used in the woodworking trades may be divided into three main classes, according to the nature of the surfaces which they are required to produce, as follows: (1) Planes used in producing plane surfaces of indefinite width, *e.g.* JACK, TRYING, JOINTING, and SMOOTHING PLANES (*q.v.*) (2) Planes for forming plane surfaces of definite and usually small width, *e.g.* RABBET PLANES, PLOUGHS, MATCH PLANES, etc. (3) Planes used for forming curved surfaces, such as ROUNDS and HOLLOWS, MOULDING and BEADING PLANES, COMPASS PLANES, *etc.*

The simple planes in Class 1 are described separately. Those in Class 2 have a narrow iron, the cutting edge of which extends to the extreme outer edge of the body or stock. They are in most cases provided with a FENCE or guide, which is pressed against the edge of the piece of wood which is being worked, and causes the plane to travel parallel to this edge. A RABBET or REBATE PLANE has a cutting iron from ½ to 1½ in. or more in width, and is used for forming a rabbet (*q.v.*) along the edge of a piece of wood. The best forms have a fence. A PLOUGH has a set of irons, from ⅛ in. in width upward; it is used for cutting grooves of various depths and at various distances from the edge of the wood. A vertical stop or fence is fitted to regulate the depth of the groove. A SHOULDER PLANE resembles a rabbet plane in form, but has no fence; the body is usually made partly or entirely of metal, and the cutting iron is set at a very acute angle. It is used in cutting across the grain in finishing off the shoulders of tenons. MATCH or MATCHING PLANES are made in pairs, with irons suitably shaped for forming tongues and grooves, etc., for joining two boards edge to edge.

Planes contained in Class 3 vary very much in the form of the cutting iron, but otherwise are very similar in pattern; they are usually without a fence when made of wood, though the American patterns usually possess one. HOLLOWS and ROUNDS are planes with cutting irons whose edge is an arc of a circle; they are made in pairs, one being concave, the other convex. BEADING PLANES have the cutting edge so shaped as to cut beads of different forms, the sole of each plane being so shaped as to fit exactly to a piece of the finished beading. COMPASS PLANES, VIOLIN MAKERS' PLANES, etc., have a curved sole and cutting edge, and are used in producing various concave and convex surfaces.

All the above planes may be made either of wood or iron; the latter have not come into common use in England, though they possess many advantages. Among these are the freedom from wear, absence of warping and cracking, etc., which prevent the plane from losing its correct shape; the better method of fixing the iron and of adjusting its exact position; the very convenient fences, etc. There are also various forms of iron plane which cannot be made in wood at all, such as a SIDE RABBET PLANE, used for planing the sides of a narrow groove, and a

CIRCULAR PLANE with a flexible steel sole, which can be bent into an arc of a circle, either convex or concave. The radius of this circle can be varied within very wide limits, and the plane used for finishing off circular work, such as carriage wheels.

Planes of Symmetry (*Min.*) Imaginary planes dividing crystals into halves which are symmetrical to one another. The cubic system has nine possible planes of symmetry, the hexagonal division of the rhombohedral system has seven, the rhombohedral division of the same system has four, the tetragonal system has five, the orthorhombic system three, the monosymmetric system, as its name implies, has only one, and the triclinic system has none.

Plane Surface, Production of. (1) MECHANICAL METHOD: Three similar plates of iron are taken, each having a surface which has been rendered approximately plane by means of a planing machine and the ordinary processes of the workshop. One of these is then covered with a film of red lead and oil, and pressed against the second plate; the projecting portions of either plate cause a patch of red lead to be transferred from the first to the second plate, and these projecting portions are removed by scraping. By proceeding in this way it is possible to make the surface of the second plate an exact counterpart of that of the first. In the same way the third plate can also be made a counterpart of the first. If now the second and third plates be compared, they will not be an exact counterpart of each other unless the first was truly plane. By the comparison of the three, taken in pairs, they can ultimately be brought to the same form, which must be a plane surface. When once such a plane surface has been prepared, it may be used as a standard by which other surfaces may be rendered plane. *See* SURFACE PLATE. (2) OPTICAL METHOD: Lord Rayleigh's method of testing the form of a surface is to fix the plate in a vessel filled with water at such a depth that the surface is about ·5 mm. under the water. If the surface be viewed by monochromatic light, any irregularities of the surface are made visible by the production of interference patterns. The projecting portions are removed by grinding or rubbing, and the test repeated until the surface becomes sufficiently regular. The method is capable of producing a very high degree of accuracy.

Plane Table (*Surveying*). An instrument consisting of a drawing-board mounted on a tripod, and with arrangements to enable an observed angle to be laid down direct on a sheet of paper stretched upon it.

Planetary Nebulæ (*Astron.*) Nebulæ which shine with a planetary and often bluish light, and are circular or slightly elliptical in form.

Planets (*Astron.*) Bodies which revolve round the sun in closed orbits, comets excluded.

Planimeter (*Eng., etc.*) An instrument which enables the area of any figure to be measured by merely drawing a tracing point attached to a system of levers round the perimeter of the figure. When the tracing point has completed its path, the extent of the area is recorded on a graduated dial. It is much used for finding the areas of INDICATOR DIAGRAMS.

Planing Machine (*Carp., etc.*) Planing machines for wood are of two distinct types. (1) Those with a fixed plane iron projecting from an opening in a table, over which the wood is drawn by mechanism. (2) Machines with rapidly revolving cutters, which may revolve about a vertical or a horizontal axis.

Planing Machine (*Eng.*) The machine used for the production of large flat surfaces. The work is caused to move in a horizontal plane, so as to be acted on by a fixed cutting tool. The latter is held by mechanism resembling a SLIDE REST (*q.v.*), so that the length and breadth of each cut can be accurately regulated.

Planishing (*Eng., etc.*) Finishing off bright metal work by hammering the surface with a smooth hammer, which is in some cases driven by machinery so as to give a very great number of light blows in a minute.

Plank. A piece of timber over 9 in. wide, generally 11 in., and from 2 in. to 4 in. thick.

Plant (*Eng., etc.*) The collection of machines and other appliances used in any particular workshop, factory, trade, etc.

Plantain (*Botany*). Like the banana, the plantain, *Musa sapientum*, var. *Paradisiaca* (*Musaceæ*), is a native of tropical climates. The plant sometimes reaches a height of 20 feet; the fruit is used as a food, and the fibres of the stem yield valuable material for cordage and paper.

Planted Moulding (*Carp. and Join.*) Moulding prepared from a separate piece of wood and fixed to any piece of joinery. *Cf.* STUCK MOULDING.

Planté's Secondary Battery (*Elect.*) *See* ACCUMULATORS.

Plaque. A decorative piece of terracotta, metal, or other material, shaped like a plate and bearing some ornamental design suited to the material upon which it is executed.

Plasma (*Min.*) A semi-translucent pale green variety of Chalcedony.

Plaster. A mixture of lime and sand. *See* CEMENTS.

Plaster Cast. *See* CAST.

Plaster, Fibrous (*Dec.*) Moulded ornaments made of plaster on a canvas backing, and used for the embellishment of ceilings, walls, etc.

Plaster of Paris. *See* CEMENTS *and* CALCIUM COMPOUNDS.

—— **Painting on** (*Dec.*) In painting with oil paint on plaster made from either Keen's or Parian cement, the paint may be applied within twenty-four hours of the plaster being executed. If, however, plaster of Paris is used, several days must be allowed to elapse. The surface having been rubbed down with sandpaper, the first coat, mixed somewhat thin, may then be applied. After twenty-four hours a second coat may be given, and this should be mixed with rather more oil than the first. Imperfections should be stopped with hard lead stopping, and after another day a third coat may be given, and after a similar interval a fourth coat. It is usual to finish the surface of a painted wall "flat," *i.e.* without gloss, and to stipple the work (*see* STIPPLING) by means of a specially made brush, which is dabbed against the paint while wet, in order to produce an uneven surface.

Plastic (*Arts*). The term applied to substances that are capable of being easily moulded or fashioned into various forms, *e.g.* clay, wax, etc.; appertaining to sculpture and the allied arts.

Plastic Clay (*Geol.*) As the name of a geological formation this is synonymous with the Reading Beds, a local type of development of the middle members of the Lower London Tertiaries. The type prevails not only near the town of Reading, but as far down the Thames Valley as Erith, and also in the Isle of Wight and adjacent parts of the South of England.

Plastic Sulphur (*Chem.*) *See* SULPHUR.

Platanus (*Botany*). A genus of the *Platanaceæ*, a Dicotyledon order. The timber of the Plane (*P. orientalis*) and Buttonwood (*P. occidentalis*) are useful woods.

Platband (*Architect.*) (1) A fascia or band, of small projection. (2) A lintel to a door or window is sometimes referred to as a Plat-band.

Plate. (1) Sheet metal. (2) Silver or gold vessels, cutlery, etc. (3) Electroplated ware. *See* ELECTROPLATING. (4) The term plate is frequently applied to some special portion of a machine or structure, *e.g.* FISH PLATE, etc.

—— (*Engrav., etc.*) A flat sheet of metal upon which some subject is engraved in order that impressions may be obtained. The term is sometimes applied to the printed impression and to illustrations appearing in books. A page of stereotype (*q.v.*)

Plate Armour. *See* ARMOUR.

Plate Columns (*Chem. Eng.*) A special form of reaction tower (such as the Lunge-Rohrmann type, etc.) used in modern methods of vitriol manufacture.

Plate Dowels (*Pattern Making*). Metal dowels used to connect two parts of a pattern which have to be taken apart for withdrawal from the mould.

Plate Edge Planing Machine (*Eng.*) A machine used for planing the edges of large plates used for making girders, etc. The sheet of metal is fixed, and the cutting tool travels along it.

Plate Furnace (*Eng.*) A form of reverberatory furnace used for heating large plates which have to be shaped for boiler work, etc.

Plate Gauge (*Eng.*) (1) Gauges consisting of flat plates used as standards of thickness. (2) Gauges with notches of known width used for gauging the thickness of plates. *See also* WIRE GAUGES.

Plate Girders (*Eng.*) Girders consisting of one large plate forming a WEB (*q.v.*) and having flanges riveted at the top and bottom.

Plate Glass. This is used chiefly for mirrors, large windows, shop fronts, etc. Before being polished it is termed ROUGH PLATE, and is translucent rather than transparent. To be made into polished plate, both sides are ground flat, smoothed and polished. The method of manufacture admits of very large sheets of plate being made. Rough plate is used for lighting, *e.g.* skylights, etc. *See* FURNACES *and* GLASS MANUFACTURE.

Plate Glazing (*Paper Manufac.*) Polishing paper by pressure. The paper is placed between copper sheets.

Plate Machine (*Elect.*) A machine for the production of charges of electricity by the friction between a flat disc or circular plate of glass and pads or rubbers; now little used.

Plate Mill (*Eng.*) A rolling mill with truly cylindrical rollers used for making sheet iron.

Plate Moulding (*Foundry*). Moulding (*q.v.*) in which the pattern is made in two halves, each half being attached to a flat plate on which the moulding box or flask (*q.v.*) is laid while being filled with sand.

Platen (*Eng.*) The flat table on which the material or work lies in planing machines, etc.

Platen Machine (*Print.*) *See* TYPOGRAPHY.

Plate Shearing Machine (*Eng.*) A shearing machine (*q.v.*) with very long cutting edges, for cutting large sheets of metal.

Plates, Iron (*Met.*) Iron plates range from a thickness 0·238 in. (No. 4 Birmingham Wire Gauge) upwards. Thicknesses below this are classified as "sheets." But the thin sheets used for tinning are called Block Plates, of which singles range from No. 4 to No. 20 B.W.G. (·238 to ·035 in.); doubles No. 20 to No. 25 B.W.G. (·035 to ·02 inch); and trebles No. 25 to No. 27 B.W.G. (·02 to ·016 in.)

Plate Tracery (*Architect.*) The form of tracery used in Early Gothic work. It consists of openings of various shapes cut through a flat slab of stone. *See* BAR TRACERY, FLAMBOYANT TRACERY, *and* TRACERY.

Plating. Covering the surface of an object (usually of metal) with a layer or coating of some more valuable metal. *See* ELECTROPLATING.

—— (*Eng.*) The marking, cutting, drilling, etc., of iron plates for boiler or girder work.

Platinoid (*Elect.*) An alloy resembling German silver, to which 1 or 2 per cent. of tungsten has been added. Used for resistance coils.

Platinotype (*Photo.*) A process of photographic printing in which the image is finally formed in platinum black. It is dependent upon the action of light on ferric oxalate, which it reduces to ferrous oxalate. The ferrous oxalate, when dissolved in a solution of potassium oxalate, instantly reduces the platinum from its chlorides and other salts.

Platinum (*Chem.*) Pt. Atomic weight, 195. A silvery white metal; melts about 2000°; specific gravity, 21·5; very malleable and ductile. When melted it dissolves oxygen, but gives it up again on cooling. The heated metal absorbs hydrogen, and a heated platinum tube allows hydrogen to pass through it. *See* OCCLUSION. Platinum causes the union of oxygen with many combustible gases and vapours; when the platinum is finely divided, that is presents a large surface, it can do this at the ordinary temperature; but ordinary platinum wire or foil requires to be warmed first. Thus a warm platinum wire will cause the union of oxygen and hydrogen to occur, and also the union of oxygen with vapour of methyl alcohol; *e.g.* if a warm platinum spiral be held over the surface of some methyl alcohol contained in a beaker, the wire will quickly become red-hot, and if the distance be carefully adjusted, will keep so, the alcohol being meanwhile oxidised to aldehyde. This property of platinum is applied in the construction of automatic gas lighters, and in the "poker" used in poker work, where the hot platinum causes the union of oxygen with the vapour of a hydrocarbon. *See also* SULPHUR TRIOXIDE *under* SULPHUR COMPOUNDS. Very finely divided platinum suspended in water displays properties closely analogous to those of enzymes. *See* ENZYMES, p. 205. Platinum is slowly oxidised on prolonged heating in oxygen; it is not dissolved by any acid.

A solution of potassium cyanide dissolves platinum, slowly in the cold, quickly on heating. Aqua Regia (*q.v.*) dissolves it, forming chloroplatinic acid, H_2PtCl_6. Chlorine converts it into platinum dichloride, $PtCl_2$, or tetrachloride, $PtCl_4$. *See* PLATINUM COMPOUNDS. Platinum is also attacked by fused caustic soda or potash, or salts of these metals, which liberate the oxides on being heated. Easily reducible metals form alloys with platinum, so that compounds of lead, zinc, and antimony should not be heated in platinum vessels. A platinum vessel is injured by heating it in a smoky flame, the carbon probably forming a carbide. Platinum always occurs uncombined in nature, but never pure; the ore contains iron, rhodium, gold, iridium, palladium, osmiridium, and copper. The ore is treated under slight pressure with diluted aqua regia, the clear solution evaporated to dryness, and gently heated to change the palladium and rhodium chlorides to less soluble lower chlorides. The mass is extracted with water, acidified with hydrochloric acid, and ammonium chloride added to precipitate the platinum as ammonium platinic chloride. The metal is obtained from this double chloride by heating it; when this double chloride is *gently* heated it leaves behind "spongy platinum," which is used in the catalytic reactions mentioned above; when the metal is to be cast it is melted in the oxyhydrogen flame. When platinum is required in a still more finely divided form—"platinum black"—the dichloride is warmed with alcoholic potash. For another form of finely divided platinum *see* ENZYMES, p. 205.

Besides the uses mentioned above for platinum it is largely used in making dishes and crucibles intended for use at a high temperature in chemical processes; and in Russia a platinum coinage was in circulation at one time. Platinum wire is used in making small incandescent electric lamps. *See also* PLATINUM COMPOUNDS. About 95 per cent. of the world's platinum comes from the Urals in Russia; the amount from Russia in 1902 was 7,306 kilograms.

Platinum (*Min.*) The native metal of the same name. Cubic, but usually in grains and nuggets up to 21 lb. troy. Colour, white; metallic lustre. Density, 16—19. The mineral contains traces of gold, iridium, rhodium, palladium, iron, osmium, and copper. The platinum varies from 45 to nearly 90 per cent. From the Urals in alluvial gravel, from which some forty tons are raised annually. From South America, Borneo, California, St. Domingo, New South Wales, etc.

Platinum Compounds (*Chem.*) OXIDES: *Platinous oxide*, PtO, is a grey powder obtained by heating platinous hydroxide at a low temperature. On heating, it decomposes into its elements; reducing agents easily convert it into the metal; it has acid properties. The platinous hydroxide is obtained as a black powder by boiling potassium chloroplatinite, K_2PtCl_4, with dilute caustic soda in the proportions of one molecule of the former to two of the latter. *Platinic oxide*, PtO_2, is a black powder which behaves both as a basic and an acid oxide; it is obtained by carefully heating platinic hydroxide. The latter is obtained by boiling a solution of platinic chloride with excess of caustic soda, and heating the precipitate with acetic acid to remove sodium. The white substance so obtained is dried at 100°, when it forms the yellow platinic hydroxide $Pt(OH)_4$. CHLORIDES: *Platinous chloride*, $PtCl_2$, is a greenish brown powder; insoluble in water; soluble in hydrochloric acid, forming chloroplatinous acid, H_2PtCl_4; decomposed on heating. It is obtained by heating finely divided platinum in dry chlorine at 240° to 250°, or by heating chloroplatinic acid at 300°. Platinous chloride unites with carbon monoxide when heated in this gas at 250°, forming three compounds, $PtCl_2CO$, $PtCl_2 2CO$, and $2PtCl_2 . 3CO$. All these compounds are decomposed by water forming hydrochloric acid, carbon dioxide, and platinum. *Platinic chloride*, $PtCl_4$: a yellow or brown crystalline solid; soluble in water; decomposed on heating. When silver nitrate is added to its solution, silver chloroplatinate is precipitated, and not silver chloride; but on warming, the chloroplatinate decomposes, giving silver chloride and a solution of platinic chloride. The aqueous solution is believed to contain the acid H_2PtCl_4O. Platinic chloride is obtained by heating the metal to a high temperature in dry chlorine, or when chloroplatinic acid is heated carefully in chlorine or hydrochloric acid gas; its crystalline hydrate, $PtCl_4 5H_2O$, may be obtained by evaporating the solution from the decomposition of silver chloroplatinate by heating it with water. *Chloroplatinic acid*, H_2PtCl_6, commonly called platinic chloride, is a reddish brown, deliquescent, crystalline solid obtained by dissolving platinum in aqua-regia and repeatedly evaporating with hydrochloric acid on the water bath to remove nitric acid. Its salts are important; the potassium and ammonium salts, K_2PtCl_6 and $(NH_4)_2PtCl_6$, crystallise alike in golden yellow crystals, and are sparingly soluble in water and less soluble in alcohol. Their formation is employed as a qualitative test for and as a means of quantitatively estimating potassium and ammonia. Organic ammonia derivatives behave like ammonium salts; *e.g.* $(C_6H_5NH_2 . H)_2PtCl_6$ is formed from aniline, $C_6H_5NH_2$. The potassium salt on heating gives potassium chloride and platinum; the ammonium salts leave only platinum behind. The sodium salt is very soluble in water. When potassium chloroplatinate is reduced by cuprous chloride, or when chloroplatinic acid is reduced by sulphurous acid, and caustic potash added till neutral *potassium chloroplatinite*, K_2PtCl_4, is formed, this salt is used along with ferric oxalate in photography in the preparation of platinotypes. PLATINOCYANIDES: These compounds are the cyanogen analogues of the chloroplatinites, and may be regarded as derived from platinocyanic acid, $H_2Pt(CN)_4$. This acid is prepared by decomposing its barium salt with its exact equivalent of dilute sulphuric acid, or its copper salt by sulphuretted hydrogen, filtering, and evaporating the solution. It forms crystals the colour of which depends on the amount of water of crystallisation they contain; *e.g.* $H_2Pt(CN)_4 5H_2O$ forms red prisms with blue reflex. Soluble in water and in alcohol; reacts acid to litmus, and decomposes carbonates; decomposes above 140° into platinous cyanide and hydrocyanic acid. *Potassium platinocyanide*, $K_2Pt(CN)_4 3H_2O$, forms yellow prisms, which appear blue when viewed in one direction; it effloresces in air; soluble in water; not decomposed at 600°. It is used in the preparation of other platinocyanides. It is obtained by heating platinum black with potassium ferrocyanide, extracting with water, filtering and crystallising; also by boiling platinum black with a concentrated solution of potassium cyanide; also by boiling ammonium chloroplatinate with caustic potash and a concentrated solution of potassium cyanide till all ammonia is driven off. *Barium platinocyanide*, $BaPt(CN)_4 4H_2O$, crystallises in rhombic prisms with a yellow colour with blue reflex, or a green colour, according to the way they are viewed;

sparingly soluble in cold water, fairly soluble in hot water. It becomes fluorescent (yellowish green) on exposure to ultra-violet light, to Röntgen rays, and to radioactive elements. It is used in making fluorescent screens for experiments on these forms of radiation, and it was by such a screen that Röntgen discovered his rays: "I was working with a Crooke's tube covered by a shield of black cardboard. A piece of barium platinocyanide paper lay on the bench there. I had been passing a current through the tube, and I noticed a peculiar black line across the paper." The black line would be a shadow cast by some object impervious to the rays. This salt is prepared by decomposing the copper salt by baryta water. The copper salt is prepared by precipitation of potassium platinocyanide by copper sulphate; it is also prepared by passing the vapour of hydrocyanic acid into hot water, in which platinous chloride and barium carbonate are suspended until carbon dioxide ceases to be evolved. MAGNESIUM PLATINOCYANIDE, $MgPt(CN)_4 7H_2O$: Crystallises in regular prisms, which exhibit a fine series of colours—red, dark red, green, blue, blue violet, according to the way in which they are viewed. Crystallised from aqueous alcohol, it gives crystals containing $6H_2O$, which are yellow with blue and green reflex. The heptahydrate loses $2H_2O$ at 40° and the resulting pentahydrate is blue; at 100° the dihydrate is formed, which is colourless. It can be prepared by the action of magnesia on platinocyanic acid, or by precipitation of a solution of the barium salt with magnesium sulphate. *Complex nitrites* of platinum are known, such as $K_2Pt(NO_2)_6$. COMPLEX AMMONIA COMPOUNDS: Very many compounds of this kind are known. They may be divided into two chief classes, *viz.* platinous and platinic compounds. In the former, one atom of platinum unites with four molecules or groups to form a complex radical, which may then act with a maximum valency of two. In the latter, one atom of platinum unites with six molecules or groups to form a complex radical, which may then act with a maximum valency of four. THE PLATINOUS COMPOUNDS: Taking as examples the ammonia and chlorine compounds, we have the following:

I. $\left\{ Pt(NH_3)_4 \right\} Cl_2 \rightarrow$ Tetrammine platinous chloride or Platodiammine chloride.

II. $\left\{ Pt{}^{Cl}_{(NH_3)_3} \right\} Cl$ Chlortriammine platinous chloride or Platochlormonodiammine chloride.

III. $\left\{ Pt{}^{Cl_2}_{(NH_3)_2} \right\}$ Platinum dichlordiammine or Platosammine chloride and Platosemidiammine chloride.

In these compounds isomerism can occur in Class III. only. To distinguish between the isomers when the first name is used, the one compound is called a cis-compound and the other a trans-compound. When the other names are used, the platosemidiammine is identical with the cis-arrangement, and the platosammine with the trans-arrangement. Besides ammonia and chlorine, a large number of other radicals can occur in these compounds, *e.g.* amines, pyridine, the sulphonic acid group SO_2OH, nitrate, sulphate groups, etc. It is clear when other groups besides ammonia and chlorine enter into these compounds, isomerism may occur with any of the classes. Examples of these compounds are *Magnus's Green Salt*, which is the platinous chloride compound of tetrammine platinous chloride, and has the formula $[Pt(NH_3)_4]Cl_2 . PtCl_2$. It is obtained by acting on a boiling solution of platinous chloride in hydrochloric acid with ammonia, and is insoluble in water and in hydrochloric acid. When Magnus's green salt is boiled with ammonia, it gives tetrammine platinous chloride, $\left\{ Pt(NH_3)_4 \right\} Cl_2$ (Reiset's first chloride). When this is heated at 250° or evaporated with concentrated hydrochloric acid, it yields the trans-platinum dichlordiammine or platosammine chloride, $\left\{ Pt{}^{Cl_2}_{(NH_3)_2} \right\}$ (Reiset's second chloride). The compound isomeric with this is obtained by the action of ammonia on potassium chloroplatinite; it is the cis-platinum dichlordiammine or platosemidiammine chloride. THE PLATINIC COMPOUNDS: Taking as examples the ammonia and chlorine compounds, we have:

I. $\left\{ Pt(NH_3)_6 \right\} Cl_4$ Hexammine platinic chloride.

II. $\left\{ Pt{}^{Cl_2}_{(NH_3)_4} \right\} Cl_2$ Tetramminechloroplatinic chloride or Platinchlorodiammine chloride.

III. $\left\{ Pt{}^{Cl_3}_{NH_3)_3} \right\} Cl$ Triamminechloroplatinic chloride or Platinchloromonodiammine chloride.

IV. $\left\{ Pt{}^{Cl_4}_{(NH_3)_2} \right\}$ Diammineplatinic chloride or Platinchloroammine or Platinchlorosemidiammine.

Isomerism has been observed in Class IV. Other radicals besides ammonia and chlorine can occur in these compounds. It is doubtful if representatives of Class I. are yet known. The platinic compounds are obtained by oxidation of the platinous compounds. In both the platinous and platinic compounds the elements or groups in the complex radical do not show their ordinary reactions. For example, the platinum is not precipitated by sulphuretted hydrogen; the ammonia is not liberated by boiling with caustic soda; the chlorine is not precipitated by silver nitrate. For an explanation of the structure of these compounds *see* WERNER'S THEORY.

Platinum Standard of Light. The intensity of illumination emitted normally by one square centimetre of platinum at its temperature of fusion. This standard is also termed the VIOLLE standard.

Platinum Temperature (*Phys.*) The temperature obtained by the measurement of the resistance of a platinum thermometer, assuming the increase of resistance to be simply proportional to the temperature. If R_{100} be the resistance at 100° C., R_0 the resistance at 0° C., and R the resistance at the unknown temperature, then the value of the latter on the platinum thermometer, *i.e.* the platinum temperature, is given by the equation

$$pt = 100 \frac{R - R_0}{R_{100} - R_0}$$

The difference between this temperature (pt) and the temperature t on the air thermometer scale is given by the equation

$$t - pt = \delta \left\{ \left(\frac{t}{100}\right)^2 - \frac{t}{100} \right\}$$

in which δ is a constant for the particular platinum thermometer used, and is found by means of an observation of a third known temperature, usually the boiling point of sulphur. *See* MEASUREMENT OF TEMPERATURE.

Platinum Thermometer (*Phys.*) *See* MEASUREMENT OF TEMPERATURE.

Play (*Eng., etc.*) (1) A limited amount of movement, regular or irregular, allowed on certain parts of a machine, etc. (2) Space for motion.

—— (*Mining*). A miner's term for a period of cessation from work with the object of limiting the working time or the output.

Play of Colour (*Min.*) The property of causing light transmitted through the mineral to break up, giving a colour effect; well seen in Opal. It is due to the refraction of the light ray in passing into the crystal from the air and out again.

Plectrum (*Music*). A small implement of tortoise-shell, ivory, or metal used for striking or picking the strings of a mandolin, etc.

Plein Jeu (*Music*). The French term for Full Organ.

Pleistocene (*Geol.*) Synonymous with Post-Pliocene (*q.v.*), Quaternary, and other names. By some geologists the term is employed for the Glacial Period or Age of Snow. During the Pleistocene Period Britain has undergone some important changes of climate, from one during which snow was precipitated instead of rain to a second, in which dry cold winds prevailed, and to a third, much the same as at present. It includes, so far as man is concerned, the Palæolithic Period, the Neolithic Period, and the Ages of Bronze and of Iron.

Pleochroism (*Min.*) The property some minerals have of appearing of different colours when viewed in different directions. Some minerals are Dichroic (*e.g.* Dichroite or Iolite), some even Trichroic.

Pleonaste (*Min.*) A black variety of Spinel (*q.v.*)

Pliers *or* **Plyers** (*Eng., etc.*) A small pair of pincers for handling small articles; used also for shaping wire.

Plinth (*Architect.*) The slab-like member forming the lowest division of a base of a column, pilaster, or pedestal. Greek bases had no plinth. The term plinth is also used to denote a slightly projecting face at the base of a wall, pier, etc.

Pliocene (*Geol.*) The subdivision of the Tertiary Period during which the percentage of recent species of marine mollusca was *more* than that of the extinct species. The period was pre-eminently the Age of Mammals. That it was one of long duration can be shown by the fact that numerous and important geographical, as well as biological, changes took place within the period. Our British Pliocene Rocks occur chiefly in East Anglia. They include the Cromer "Forest Bed" and the various "Crags," such as the Red Crag, Coralline Crag, etc.

Plot *or* **Plat** (*Mining*). (1) A flat place, especially one on which ore is to be laid or piled. (2) A rough bridge with a flat roadway.

Plotting (*Chem. Eng.*) The process of compressing or "squirting" a milled soap into a compact bar by forcing the ribbons of soap through a nozzle. The process is often called plodding, but the term is really derived from the French *pelotage*.

—— (*Eng., etc.*) Drawing a curve or line through a series of points, the position of which has been determined by calculation, experiment, or otherwise.

Plough (*Bind.*) The instrument used for cutting the edges of a book when it is in the lying press. *See* BOOKBINDING.

Plough (*Carp. and Join.*) A tool with a movable fence, for cutting grooves of various sizes in joinery. *See also* PLANES.

—— (*Elect.*) The conductor which makes contact with the live rail in an electric railway or tramway on the slotted conduit system.

Ploughed and Tongued Joint (*Carp. and Join.*) A joint for joining boards together. The edges are grooved and a tongue inserted.

Ploughshare Vault (*Architect.*) A vault in which the cells (*q.v.*) are winding surfaces. It is a form peculiar to Gothic work.

Plug (*Eng., etc.*) (1) A general term for a piece of material of suitable shape, used for filling up a hole. (2) The movable part of a tap or cock. (3) A piece of iron with a male thread to stop the end of a gas or water pipe.

Plug Centre Bit (*Carp.*) A form of PIN DRILL (*q.v.*) used for making holes in wood.

Plug Gauge (*Eng.*) A cylindrical piece of metal accurately turned to a given size and used as a standard of measurement.

Plug Key *or* **Switch** (*Elect.*) A device for making and breaking a circuit by means of a metal plug fitting a recess between two blocks of metal placed close together.

Plug Tap (*Eng.*) A tap used for finishing off an internal screw thread; it is made without any taper (*q.v.*)

Plum. *See* WOODS.

Plumb. *See* PLUMB LINE, PLUMB RULE.

Plumbago. A popular synonym for GRAPHITE (*q.v.*)

Plumbago Crucibles (*Met.*) Crucibles made of a mixture of ground plumbago and clay. They will stand great heat.

Plumb Bob. The weight used at the end of a plumb line; it is often pointed at its lower end.

Plumber Block (*Eng.*) *See* PLUMMER BLOCK.

Plumber's Cloth (*Plumb.*) The pad used for wiping (*q.v.*) lead pipe joints.

Plumber's Iron (*Build.*) An iron used for overcasting (*q.v.*) a wiped joint.

Plumbing. The execution of lead work in building operations, *i.e.* the formation of lead roofs, flashings, domes, finials, breaks, piping, and various work, not necessarily in lead, which is connected with the foregoing.

Plumb Line (*Eng., Build., etc.*) A cord with a metal weight at the end; used to test the position of lines and surfaces required to be vertical. A vertical line.

Plumb Rule (*Build.*) A narrow piece of board with parallel sides and an egg shaped hole at the bottom end for the plumb bob to swing in. Used by masons, bricklayers, and others for determining a perpendicular.

Plumbum, Plumbic, Plumbous (*Chem.*) PLUMBUM is the Latin name for lead. The chemical symbol for lead, Pb, is derived from the word plumbum. The words plumbic and plumbous are sometimes used in naming lead salts.

Plummer Block (*Eng.*) A casting which carries the brasses forming the bearing of a shaft. The brasses fit into a suitably shaped opening in the block, and are held in place by a CAP bolted to the main casting. The latter is furnished with projections or flanges, by which it is itself bolted down to the baseplate, etc.

Plumping (*Leather Manufac.*) A swelling of the leather during the tanning process, generally dependent on the quantity of acid in the tan liquors.

Plunger (*Eng., etc.*) (1) The piston of a hydraulic press (*q.v.*) (2) The solid piston of a force pump. *See* PUMPS. (3) An implement used to form the interior of certain kinds of cheap glassware when cast in a mould.

Plush (*Silk Manufac.*) A form of velvet having a long pile, usually made in power loom, two widths being woven together face to face, the process of cutting them apart creating the pile.

—— (*Textile Manufac.*) A pile fabric in which the pile is longer than velvet and very frequently consists of mohair yarn. Used for decorative purposes.

Plus Thread. A thread cut on a bolt or rod that has been thickened where the thread occurs, so that the diameter of the substance is not reduced by the thread.

Plutonic Rocks (*Geol.*) Eruptive rocks which have consolidated from a fluid state under very great pressure and at a very slow rate. In most cases, if not in all, they probably represent the deeper seated portions of the great masses whose upper parts have been volcanoes. The exposure of Plutonic Rocks at the surface, therefore, implies upheaval and denudation to an enormous extent. Granite, Syenite, Diorite, and Gabbro are the chief varieties. Plutonic Rocks may be classed, in regard to the depth at which consolidation took place, as Sub-Plutonic, Plutonic, and Ultra-Plutonic.

Pluviometer *or* **Pluviameter** (*Meteorol.*) A rain gauge.

Ply. (1) A bend, turn, or plait. (2) A single thickness or strand.

Pneumatic Action (*Music*). A form of action employed in organ construction to lighten the touch. *See* ORGAN, p. 439.

Pneumatic Mechanism. Mechanism actuated by compressed air, however supplied.

Pneumatics. The science dealing with the mechanics of gases.

Pneumatic Tyres. *See* TYRES.

Pochettino (*Music*). A little: slightly.

Pocket (*Build.*) A term of wide application, signifying an opening or hole, *e.g.* the hole left in brickwork or masonry to receive the end of a joist or girder.

—— (*Carp. and Join.*) The rectangular hole cut in the pulley styles of a cased frame to receive the weights.

—— (*Eng.*) A general term for a recess or cavity in any structure.

—— (*Mining*). A cavity containing a mass of ore which does not form a continuous vein.

Pocket Knife (*Carp. and Join.*) A broad tool similar to a chisel, used for cutting the pockets in sash frames.

Pocket Print (*Foundry*). A core print (*q.v.*) which is not permanently fixed to the pattern, but is detached when the latter is lifted, and withdrawn separately.

Poco (*Music*). Little: rather: as *poco a poco*, little by little, gradually; *poco più mosso*, rather faster.

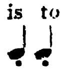
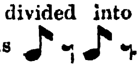
Podium (*Architect.*) A continuous pedestal, either supporting a range of columns or acting as a parapet. Like a pedestal, it consists of a base, die, and cornice. The term podium is also used to denote the wall surrounding the arena of an amphitheatre. *See* PEDESTAL *and* AMPHITHEATRE.

Podophyllum (*Botany*). A genus of the *Berberidaceæ*, *P. peltatum* (May Apple), yields a medicinal resin extracted from the rhizome and rootlets. The plant grows extensively in the eastern part of North America and in the valleys of the Himalayas.

Poikilitic (*Geol.*) Variegated or mottled. A term applied to the pale green decoloration patches which often occur in red marls or sandstones. Being of common occurrence in the New Red Rocks, the presence of this mottling has led to the whole of the New Red (*i.e.* "Permian" and "Trias" together) being classed as the Poikilitic Series.

Point (*Civil Eng.*) A movable rail used in making a connection between one set of railway lines and another. *See* RAILWAYS.

—— (*Typog.*) The unit of a lineal inch from which the various sizes of types are regulated. It is based on the fact that 72 pica ems are equal to a lineal foot, 12 points to 1 pica em, and 6 pica ems to 1 lineal inch. (*See* TYPES.)

—— *or* **Dot** (*Music*). This sign • placed after a note or rest increases its value by one half. If there are more dots than one, each succeeding dot is one half the value of that immediately before it, *e.g.*  equals . A point or dot placed above or below a note indicates that the note is to be divided into half note, half rest, *e.g.*  equals  This is called staccato (*q.v.*)

Point Bar (*Lace Manufac.*) A suitably shaped bar of iron, extending the whole width of the lace machine, to which the "point leads" are screwed. Each point or needle is adjusted in correct line with each carriage in the machine, and a peculiar dipping movement is communicated to the bar which enables the points to enter between the warp and bobbin threads and forward each twist, from its formation at the end of the carriage, through the few intervening inches to the centre or point where the fabric commences to be formed. *See also* POINTS *and* LACE MANUFACTURE.

Point d'Esprit (*Lace Manufac.*) A fine net, with small but well defined spots.

Pointed Work (*Build.*) (1) Masonry dressed with a pointed tool. (2) Brickwork or masonry in which the joints have been finished off by POINTING (*q.v.*)

Pointers (*Astron.*) Two stars in the constellation Ursa Major (the Great Bear) which point to the Pole Star and enable it to be found easily.

Point Holes (*Print.*) Pricks made in the special positions in the margins of a sheet of paper at the moment of printing. When the sheet is reversed the points are placed in the holes and register the work.

Pointing (*Build.*) Forming and finishing the external joints of brickwork and masonry so as to give a neat appearance to the work. The operation is performed by raking out a portion of the mortar between the joints of brick or stone walls in order to replace it by new mortar, which is finished off or smoothed on the surface with a tool.

—— (*Sculp.*) Marking off points on a clay model to facilitate and ensure accurate reproduction in marble, bronze, etc.

Point Net (*Lace Manufac.*) A net made by the aid of a needle.

Point Net Machine (*Lace Manufac.*) A "warp machine" (*q.v.*)

Point Pass (*Textiles*). *See* ENTERING.

Points (*Lace Manufac.*) A series of needlelike instruments arranged with geometrical precision upon a bar called the point bar (*q.v.*) They serve to take up the twist and crosses or intersections in the net.

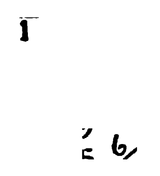
—— (*Print.*) Pins or spurs fastened to the tympan of a hand press, or fixed in the margins of a forme when printed on a cylinder machine, for the purpose of securing register when perfecting the sheet.

Point Screws (*Print.*) A small screw and nut for clamping points to the tympan frame of a hand press.

Points of the Compass. The dial of a compass is divided into four principal quadrants by lines running diametrically across from N. to S. and from E. to W. Each quadrant is bisected by a diameter running N.E. to S.W. and N.W. to S.E. Each of these eight divisions is again divided into four, constituting the thirty-two points of the compass. These points are named as follows:

N.,	N. by E.,	N.N.E.,	N.E. by N.
N.E.,	N.E. by E.,	E.N.E.,	E. by N.
E.,	E. by S.,	E.S.E.,	S.E. by E.
S.E.,	S.E. by S.,	S.S.E.,	S. by E.
S.,	S. by W.,	S.S.W.,	S.W. by S.
S.W.,	S.W. by W.,	W.S.W.,	W. by S.
W.,	W. by N.,	W.N.W.,	N.W. by W.
N.W.,	N.W. by N.,	N.N.W.,	N. by W.

Points of the Shield (*Her.*) The parts denoting the position of any figure. The shield is divided into nine points.



1. Dexter Chief.
2. Middle Chief.
3. Sinister Chief.
4. Dexter Base.
5. Middle Base.
6. Sinister Base.
7. Honour Point.
8. Fesse Point.
9. Nombril Point.

Polar. Belonging or relating to a POLE (*q.v.*)

Polar Axis (*Astron.*) The axis of an equatorial telescope, adjusted to the latitude of the place in question.

Polar Caps (*Astron.*) Some of the planets, *e.g.* Mars and Venus, have white caps at their poles which vary in size according to the planets' seasons.

Polar Climate (*Meteorol.*) The principal characteristics of the climate of the polar or frigid zone, such as the absence of solar rays during a longer or shorter portion of the year.

Polar Distance (*Astron.*) The angular distance of a star from one of the celestial poles. The North and South Polar Distances are abbreviated to N.P.D. and S.P.D.

Polaris (*Astron.*) The North Pole Star, about which all the other stars appear to revolve.

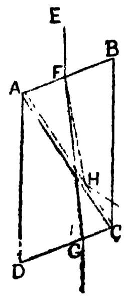
Polarisation in a Dielectric (*Elect.*) Let a unit area be drawn in a dielectric at right angles to any line AB; then the polarisation in the direction AB is the difference between the number of Faraday tubes (*q.v.*) which pass from one side of the area to the other in the direction AB, and the number which pass in the opposite direction, BA.

Polarisation of a Cell (*Elect.*) A temporary decrease in the electromotive force of a cell, owing to certain changes in the substances in contact.

Polarisation of an Electrolyte. The separation of free ions at the electrodes, resulting in the production of an electromotive force in the opposite direction to that producing the separation of the ions.

Polarisation of Light (*Phys.*) Light is said to be POLARISED when the type of the vibration is maintained invariable (*Preston*). In this case every element or particle of the ether describes the same kind of curve in the course of its vibrations; or, more generally, the nature of the disturbance remains permanently unaltered. If the elements are executing vibrations in parallel straight lines, the light is said to be PLANE POLARISED; if the paths are circular, the light is CIRCULARLY POLARISED; if they are ellipses, which are similar and similarly situated, the light is ELLIPTICALLY POLARISED. A beam of plane polarised light has its vibrations confined to a single plane; they are transverse and analogous to the vibrations of a plucked string, all particles of which are executing vibrations in parallel rectilinear paths. Thus the polarised beam is *two sided*, and it is by this property that the existence of the polarisation is detected. Light may be plane polarised in a variety of ways, of which the following are the chief:—(1) BY REFLECTION: Light reflected from any surface is in general partly polarised, *i.e.* the reflected beam is a mixture of polarised and unpolarised, or ordinary, light. The amount of polarisation is a maximum for one particular angle, which is termed the POLARISING ANGLE for the substance. In the case of a transparent substance, when some of the light is reflected from the surface and some is transmitted, the polarising angle is that angle of incidence for which the reflected and the transmitted rays are at right angles; if ϕ be the polarising angle and μ the Refractive Index for the medium, then $\tan\phi = \mu$; this is BREWSTER'S LAW. For glass the angle is about 57°. If, then, ordinary light be incident on a glass plate, or, still better, a pile of plates, at this angle, the reflected ray is plane polarised. (2) BY TRANSMISSION: In the above case it is found that not only the reflected ray, but also the refracted ray, is plane polarised; both portions contain the same amount of polarised light, and their planes of polarisation are at right angles to each other. But whereas the reflected beam is practically completely polarised, the transmitted contains an equal amount of polarised, mixed with a large excess of ordinary light. Each plate acts similarly, hence a sufficient number will completely polarise transmitted rays, when the incident light strikes the surface at the polarising angle. (3) BY DOUBLE REFRACTION (*q.v.*): Both the Ordinary and Extraordinary Ray are plane

polarised in directions at right angles to each other. A pinhole in a card, viewed through a crystal of Calcite, gives two images, the beams of light from each being polarised. A plate of Tourmaline, if cut parallel to the axis of the crystal, will, under the same circumstances, show one image only; two beams are really produced, but the Ordinary beam is absorbed, unless the plate be extremely thin. We thus obtain a single beam of polarised light. For experiments on polarised light we require a device to polarise the light, which is termed a POLARISER, and an ANALYSER, whereby the polarisation may be detected. The two form a POLARISCOPE. Consider a beam which has been plane polarised by any of the means referred to above. Interpose in the path of the beam a second arrangement exactly similar to that by which the light was originally polarised. This forms the Analyser. If the two polarising devices be similarly situated (*i.e.* if the second one be so placed that it will polarise a beam of ordinary light in the same plane as the first does), then the beam passes through both Polariser and Analyser. Now rotate the Analyser; the transmitted beam diminishes in intensity, and becomes completely extinguished when the Analysis has been turned through a right angle. If we suppose the Polariser to be so placed that the vibrations which it transmits are confined to a *horizontal* plane, then the Analyser will be so turned that it only transmits vibrations in a *vertical* plane; therefore, if the vibrations are of a transverse nature, none can pass through the two in succession, and extinction of the beam occurs. The most usual method of polarising light is by means of a NICOL'S PRISM, or, as it is often termed, a NICOL. A crystal of Iceland Spar, ABCD, is cut across along AC, and the two halves cemented together by a film of Canada Balsam. The Index of Refraction of this substance is less than that of the crystal for the Ordinary Ray, but greater than its value for the Extraordinary Ray. When a ray EF entering the prism is split up into two rays FH and FG by double refraction (*q.v.*), it is therefore possible to get rid of the Ordinary Ray by total internal reflection (*q.v.*) at H, while the Extraordinary Ray passes through, and emerges at G as a plane polarised ray.



A Nicol Prism can be used either as a Polariser or Analyser. Various other polarising prisms have been invented, varying chiefly in the methods employed in order to effect a separation of the two rays of polarised light produced in a doubly refracting medium. When the Polariser and Analyser of a polariscope are so placed as to cut off the passage of light, they are said to be "crossed." Any doubly refracting transparent substance placed between the crossed Polariser and Analyser will (except in certain positions) cause light to pass. This is because the velocity of light in the substance varies with direction of path, and the form of the incident vibration hence passes through cycles of change of the Lissajou figure type, but limited to straight line, ellipse, and circle, so that the beam may emerge elliptically or circularly polarised, and then its vibrations cannot be completely stopped by the Analyser. This effect, common to all doubly refracting substances, must be distinguished from the ROTATION OF THE PLANE OF POLARISATION produced by a few crystals, of which quartz is the most important, and by many organic liquids and solutions. In this case the emergent beam is still plane polarised, but its direction of vibration has been rotated through a certain angle. If this rotation is clockwise, *looking along direction the light travels*, it is said to be RIGHT HANDED, and *vice versâ*. It may be distinguished from ordinary double refraction as follows: A plate of any doubly refracting substance cut perpendicular to the axis does not restore light when placed between crossed Polariser and Analyser, behaving like ordinary bodies. But a plate of quartz so cut *does* give light, which with white light goes through a sequence of colours, but cannot be extinguished by rotating Analyser. With monochromatic light the field can be darkened by rotating analyser, and thus the angle of rotation measured. The rotation is said to be RIGHT HANDED if it appears to the observer to be in the direction of the hands of a clock, LEFT HANDED if in the reverse direction. The amount of rotation is proportional to the thickness of the layer of the substance through which the light passes, and (in the case of solutions of optically active substances) to the strength of the solution. The latter property affords a convenient means of comparing the strengths of solutions of a given optically active substance (*e.g.* sugars). The solution is placed in a tube having its ends closed by flat plates of glass; the tube is inserted between the Polariser and Analyser, and the rotation of the latter measured by means of a circle divided into degrees and provided with a vernier. To enable the exact position of extinction to be observed, some additional device is commonly used in conjunction with the Analyser proper. That due to Laurent, termed a HALF SHADE analyser, consists of a semicircular plate of quartz cut parallel to the axis, and joined to a similar semicircle of glass of suitable thickness. When the two halves of this composite disc appear equally illuminated, the Analyser has been turned into the exact position. The BI-QUARTZ Analyser has two semicircles of quartz, one being right handed, the other left handed in their action on plane polarised light. The two halves show in general different colours, but assume the same tint when the Analyser is correctly adjusted. An instrument for comparing the rotation produced by liquids is chiefly used in estimating the strength of sugar solutions, and is consequently termed a SACCHARIMETER. The POLARISING MICROSCOPE is much used in the study of minerals. It consists of a microscope provided with a polariser and an analyser, generally formed by Nicol prisms. Minerals examined by polarised light show distinctive characteristics, and therefore the polarising microscope is much used by petrologists and mineralogists in the identification of those minerals which are naturally transparent or which can be cut into sufficiently thin slices to enable them to transmit light. A great number of phenomena are produced by polarised light under different circumstances. If the light form a convergent or divergent beam, plates of doubly refracting material (*e.g.* crystals) give a variety of geometrical patterns, depending on the direction of the axis of the crystal, whether it be uni-axal or bi-axal, etc. These patterns form rings, crosses, and complex series of curves. If the original light be white, these are brilliantly coloured: if monochromatic, they are simply light or dark bands. To show these figures, an arrangement of lenses is used to cause the light to form a convergent beam before passing through the substance to be examined. Such an arrangement may be fitted to an ordinary table polariscope, a lantern polariscope for projection on the screen, or to a polarising microscope.

Polariscope. *See* POLARISATION OF LIGHT.

Polarised Light. *See* POLARISATION OF LIGHT.

Polarised Relay (*Elect. Eng.*) A RELAY (*q.v.*) having a permanent magnet instead of a core of soft iron.

Polariser (*Light*). *See* POLARISATION OF LIGHT.

Polarity. The possession of magnetic poles; the property acquired by a magnetisable body when brought into a magnetic field.

Polar Radius of the Earth. *See* RADIUS OF THE EARTH.

Polar Relay (*Elect. Eng.*) *See* POLARISED RELAY.

Pole Armature (*Elect. Eng.*) *See* ARMATURE.

Pole Lathe. A primitive lathe with Dead Centres (*q.v.*) in which a cord is wrapped round the work. One end of this cord is attached to a treadle, the other end to a flexible pole. Rotation is produced by pressing the treadle, and then releasing it, the pole drawing the cord up again. The pole lathe is still met with occasionally, *e.g.* it is used in the production of chair legs in the High Wycombe district. In Eastern countries it is fairly common.

Pole Plate (*Carp. and Join.*) The horizontal timber that supports the feet of the rafters of a roof over a void. *See* ROOFS.

Poles (*Elect.*) The terminals of a cell, condenser, etc.

——, **Celestial** (*Astron.*) Two points situated 90° from the celestial equator, or two points in the sky where a star would have no diurnal motion.

——, **Magnetic.** In general language, the ends of a magnet or magnetised bar; the parts of the magnet at which the magnetic properties appear to be chiefly concentrated. If the poles of a magnet were true mathematical points, then the lines of force would start off radially from these points. This condition is never fulfilled, but is most nearly approached in the spherical ended magnets invented by Robeson and Searle. *See* ROBESON MAGNETS.

——, **Terrestrial** (*Astron.*) The extremities of the Earth's axis.

Poles of a Great Circle (*Geom.*) The two points situate 90° from the circumference of a great circle; the extremities of the axis of the great circle, *i.e.* the extremities of that diameter of a sphere which is at right angles to the great circle. *See also* SPHERE.

Polianite (*Min.*) Manganese dioxide, MnO_2: tetragonal and isomorphous with tinstone. Compare with the allotropic PYROLUSITE.

Poling (*Met.*) The reduction of the copper oxide in Blister Copper by the insertion of a pole of green wood. The gases evolved from the wood serve as reducing agents, and also cause the fluid metal to splash up and come into intimate contact with a layer of pure anthracite or charcoal, which is spread on the surface. When the process has been carried sufficiently far, the metal is said to be at TOUGH PITCH, and is ready for use. If the process is incomplete, the metal is said to be DRY or UNDERPOLED, and is brittle; while if carried too far, the metal is OVERPOLED, and must be slightly oxidised by the exposure of the surface of the fluid metal to the action of the air.

Poling Boards (*Build., etc.*) The retaining boards that prevent the earth from falling, in a trench.

Polisher or Polishing Iron (*Bind.*) A steel finishing tool which is heated and passed over the back and sides of leather bindings to smooth down burrs and impart a gloss to the leather.

Polishing Lathe or Head (*Eng., etc.*) A small headstock fitted with a mandrel carrying a rapidly rotating polishing wheel or brush.

Polishing Stick (*Eng., etc.*) A strip of wood covered with emery or buff leather, used for polishing metal work in the lathe.

Polishing Wheel (*Eng., etc.*) A small wheel coated with buff leather, or covered with fine emery, carborundum, or other polishing powder.

Polissoir (*Glass Manufac.*) A block of wood attached to a rod of iron with which the flattener transforms the cylinders into flat sheets. *See* SHEET GLASS *and* GLASS MANUFACTURE.

Pollard Oak Graining (*Dec.*) Is a favourite method of imitating wood by British grainers. The wood imitated is supposed to be old stumps of trees having a variety of grain almost equal to French walnut. It is sometimes called "root of oak." The ground colour is made by mixing yellow ochre and white lead with a little Venetian red and dark umber until the requisite depth is obtained. It should, however, be lighter than walnut. The graining is done with raw and burnt sienna, Vandyke brown and burnt umber, and a little ivory black and ultramarine may also be employed.

Pollen (*Botany*). Minute grains containing the male element necessary for fertilisation in a flowering plant.

Polonium (*Chem.*) The first radioactive element isolated by the Curies from pitchblende. It seems doubtful if it is really an element. *See* RADIUM.

Polybasite (*Min.*) A silver sulphantimonite, $9Ag_2S \cdot Sb_2S_3$. Rhombic; colour, iron black. It contains about 70 per cent. of silver, and hence is very valuable when in sufficient quantity. From Mexico, Chili, etc.

Polygon. A plane figure, bounded by straight lines, more than four in number.

Polygonaceæ (*Botany*). A dicotyledon order, including the Dock, Rhubarb, and Buckwheat.

Polygonal Rubble (*Build.*) Masonry built of stones worked to polygonal shape.

Polygon of Forces. *See* GRAPHIC STATICS.

Polyhedral Angle. The figure produced by four (or more) planes which meet at a point.

Polyhedron. A solid bounded on all sides by plane surfaces.

Polymer (*Chem.*) *See* POLYMERISM.

Polymerisation (*Chem.*) *See* POLYMERISM.

Polymerism (*Chem.*) The union of two or more molecules of the same substance to form a more complex molecule which can be resolved on heating into its components. The actual change is called polymerisation: the original simple molecule and the final complex molecule are called polymers. Substances are also called polymeric when the molecular formula of one of them is an exact sub-multiple of that of the others, even when the substances are not mutually convertible into each other. Polymerisation is distinguished from condensation (*q.v.*) by the reversibility of the former process. In many cases the molecular weight of the polymer is unknown; in such cases the formula of the polymer of unknown molecular weight is expressed by writing down that of the substance which has undergone polymerisation and adding the suffix *n*. Examples: Common

phosphorus, P_4, polymerises on heating to red phosphorus, $(P_4)_n$. Aldehyde, C_2H_4O, polymerises on standing to paraldehyde, $(C_2H_4O)_3$, and, on adding a little strong sulphuric acid and keeping the temperature below 0°, to metaldehyde, $(C_2H_4O)_n$. Many other aldehydes also polymerise. Unsaturated hydrocarbons and their halogen substitution products very commonly polymerise; *e.g.* acetylene, on heating, forms benzene, $3C_2H_2 = C_6H_6$; and monochloracetylene easily polymerises to trichlorbenzene, $3C_2HCl = C_6H_3Cl_3$; cyanogen, C_2N_2, polymerises to $(C_2N_2)_n$, and cyanic acid, CHNO, to cyanuric acid, $C_3H_3N_3O_3$.

Polymorphism (*Min.*) Crystallisation of a mineral in more than three different systems.

Polyoses *or* **Polysaccharides** (*Chem.*) See CARBOHYDRATES.

Polyphase Currents (*Elect. Eng.*) Two or more alternating currents differing from each other in phase by a constant amount.

Polyphase Dynamo *or* **Generator** (*Elect. Eng.*) A dynamo for producing polyphase currents. See DYNAMO.

Polyphase Motor (*Elect. Eng.*) A motor worked by a polyphase current.

Polysaccharides *or* **Polysaccharoses** (*Chem.*) Substances belonging to the carbohydrate class, such as starch, cellulose, dextrines, glycogen, inulin, etc., all of unknown and probably high molecular weight, and having the empirical formula $(C_6H_{10}O_5)_n$.

Pomposo (*Music*). Pompously.

Ponty (*Glass Manufac.*) A tapering solid rod of iron sometimes called the WORKING IRON. See GLASS MANUFACTURE.

Poor Lime (*Build.*) A lime containing from 15 to 30 per cent. of impurities insoluble in acid.

Poplar. See WOODS.

Poplin (*Textile Manufac.*) A plain cloth, woven as tabby, with a fine ribbed lustrous appearance. Made from silk warp and a fine worsted shoot. Inferior grades are made without any silk.

Poppet (*Eng.*) The loose head of a lathe which supports the end of a long piece of work.

Poppyhead (*Architect.*) An ornament used occasionally in Decorated and frequently in Perpendicular Gothic architecture, as a termination to bench ends in churches. These poppyheads were frequently richly carved either with leaves or grotesque figures.

Poppy Oil (*Dec.*) This oil is obtained either by pressure or by means of solvents from the seeds of the opium poppy (*Papaver somniferum*). The best varieties are almost white. The drying qualities of poppy oil are almost equal to those of linseed oil. It is used principally by artists, but abroad it is frequently employed for grinding white paints, such as zinc oxide and white lead, where a brilliant white surface is desired. Specific gravity, ·924 to ·926.

Porcelain. A specific kind of pottery manufactured from highly refined earths and mineral salts. In the process of manufacture it loses its earthy character and becomes a new and valuable material. It is characterised mainly by purity of colour and a fine translucency, even when made comparatively thick. It is non-absorbent and highly resonant when struck. See POTTERY AND PORCELAIN.

Porcupine Roller (*Lace Manufac.*) An intermediate roller either with inserted pins or covered with wire card-cloth. It is contiguous to the work roller, and serves to give a more constant "take up" of the fabric. It also ensures greater regularity in the quality of the manufactured web.

Porgie. The raw material (partly offal) from which fish oil is extracted. The term is chiefly peculiar to the Atlantic Coast of North America. Also termed MENHADEN.

Porous Pot *or* **Cell.** A vessel of unglazed earthenware used in primary cells, through the material of which the fluids of the cell can percolate, thus establishing electrical connection (through the walls of the pot) between the inner and outer parts.

Porphyrite (*Geol.*) A name originally employed in a very loose sense to denote a decomposed lava somewhat near andesite in composition, so that even trachyte lava and basalt lava sometimes went by this name. The modern use of the word is limited to the trappean representatives of the diorites at the one end of the series and the andesite at the other. The rock consists essentially of plagioclase felspar and ferromagnesian silicates, generally exclusive of olivine, in about equal proportions to each other, and in which the structure consists essentially of an older generation of larger idiomorphic crystals of these minerals set in a finer grained matrix of the same minerals of later consolidation.

Porphyritic Structure (*Geol.*) Many eruptive rocks have consolidated in part under an earlier set of conditions, and partly and finally under another. Under the earlier conditions certain of the constituents separate out and complete their growth, while the remainder of the rock is still fluid. Under the later conditions, which are usually those of lesser pressure and lower temperature, the crystallisation of the remainder takes place. Hence the earlier generation of crystals may present some special characteristic, usually in regard to size, as compared with those of the later generation. The present term usefully expresses that fact.

Porphyry (*Geol.*) A lithological term now seldom employed in scientific descriptions on account of the loose and ill-defined manner in which it was used. It originally meant (as its name implies) a certain eruptive rock of a purple colour. Then it came to be used for any kind of eruptive rock in which there was a conspicuous development of large idiomorphic crystals in a finer grained base.

Porpoise (*Zool.*) The genus *Phocæna* of the Cetacean family *Delphinidæ*. The porpoises are found in shoals in the seas around our coasts. The oil and skin are used in manufactures.

Porpoise Oil. Sometimes sold as "brown fish oil"; is obtained by boiling the flesh and fat of the porpoise. The specific gravity at 15° C. is 0·922.

Porry (*Silk Manufac.*) The stretch of warp from cane roll to harness, in which the lease or cross rods are placed.

Port (*Eng.*) See PORTS.

Portable Engine. Small engines mounted on wheels for removal by horses, etc., but distinguished from TRACTION ENGINES (*q.v.*) or road locomotives, which can travel by their own motive power. The ordinary pattern resembles the traction engine in form, and has a similar boiler to a locomotive.

Portamento, Portando (*Music*). Gliding from one note to another.

Portcullis (*Architect.*) A gate of iron or of wood strengthened with iron. It slid vertically in coulisses or channels formed in the jambs of a gateway, and was used in Roman and Gothic architecture for the purpose of defence. An ornament resembling a portcullis was frequently used in the Perpendicular style of Gothic architecture.

—— (*Her.*) Representations are used in heraldry, and the portcullis was a device of the Beauforts, thence by descent that of the Tudors, and was used by the Tudor Henrys. Also used by Westminster City and Abbey. One of the pursuivants of the College of Arms is entitled Portcullis.

Portee (*Silk Manufac.*) Twice the usual number of threads passing from warp bobbins on to the mill in the process of hand warping. Warping from forty-one bobbins (a number often used when organzine is fine), the ends from these bobbins passing once on to the mill, to the required length of the warp, is a HALF PORTEE.

Porter (*Linen Manufac.*) This term is used in Scotland as an equivalent to beer in Ireland, and means forty threads of warp. *See* BEER.

—— (*Met., etc.*) A bar attached to a forging or fagot (*q.v.*), by which it is held during hammering.

Port Holes (*Eng.*) *See* PORTS.

Portico (*Architect.*) A colonnade in front of a classic or Renaissance building. *See* COLONNADE PERISTYLIUM *and* STOA.

Portico "in-antis" (*Architect.*) *See* ANTA.

Portland Beds (*Geol.*) Rocks of marine origin pertaining to the Upper Jurassic Series overlying the Kimeridge Clay, and followed by the estuarine and fluviatile Purbeck and Wealden Strata, which form the uppermost part of the Jurassic Rocks in Britain. The Portland rocks are best exposed on the south coast of England, where they yield building stones of great value.

Portland Cement (*Build.*) An artificial hydraulic cement composed of the diluvial clay of the valleys of our chief rivers, mixed in definite proportions with the chalk of the same geological districts. These materials are finely comminuted in mills, mixed with water, allowed to deposit, then desiccated and burnt to a point which produces vitrification. *See* CEMENTS.

Portland Stone. *See* BUILDING STONES.

Portland Vase. *See* VASES.

Portrait Gallery, National. *See* NATIONAL PORTRAIT GALLERY.

Ports (*Eng.*) The openings by which steam enters and leaves the cylinder of an engine.

Porty (*Foundry*). A moulder's name for a large core print.

Posaune (*Music*). (1) Trombone. (2) An organ reed stop of rich and powerful tone—of 8 ft., 16 ft., or 32 ft. tone. *See* ORGAN, p. 441

Pose (*Art*). The attitude or posture assumed by an individual for artistic purposes. The attitude of a painted or sculptured figure.

Positif (F.), Positiv (G.) (*Music*). Choir organ. *See* p. 440.

Position Circle (*Astron.*) A divided circle fitted to telescopes for the measurement of angles of position.

Position Isomerism (*Chem.*) *See* ISOMERISM.

Positive (*Music*). The German name for Choir Organ. *See* ORGAN, p. 440.

—— (*Weaving*). As applied to a shedding motion, a positive tappet or dobby is one which controls the movement of a heald in either an upward or a downward direction. *See* NEGATIVE.

Positive Charge (*Elect.*) A charge of electricity of the same kind as that produced when a glass rod is rubbed with silk.

Positive Crystal (*Phys., etc.*) A UNIAXAL CRYSTAL (*q.v.*) in which the velocity of the Extraordinary Ray is (except along the Optic Axis) less than that of the Ordinary Ray. Quartz and Ice are examples of positive crystals. *See also* DOUBLE REFRACTION.

Positive Direction of Lines of Force (*Elect.*) The direction along which a positive charge or positive pole would travel if free to move through the medium in which the lines of force are situated.

Positive Lead, Wire, etc. (*Elect. Eng.*) The wire, etc., connected to the positive terminal of a source of electric current.

Positive Pole (*Elect.*) The terminal connected to the copper plate or its equivalent in a primary cell; the corresponding terminal, *i.e.* the one from which the current flows, in the case of a dynamo, etc.

Positive Stress (*Eng.*) A compressional, as distinguished from a tensional stress.

Post (*Paper*). Printing paper 19½ in. by 15¼ in. in size.

—— (*Paper Manufac.*) A pile of hand-made sheets of paper in the wet state, separated by "felts."

Postern (*Archæol.*) A narrow door or gate affording entrance for foot passengers to a fortified town or castle.

Poster Stick (*Typog.*) A long wooden composing stick, used for broadside and poster work.

Post Horn (*Music*). An instrument of various lengths giving the sounds of the 2nd, 3rd, 4th, 5th, and 6th harmonics of the fundamental note, originally used by mail drivers.

Posticum (*Architect.*) *See* CELL.

Post Office Box (*Elect.*) A form of Wheatstone's Bridge, convenient for transit and used in the Postal Service. *See* WHEATSTONE'S BRIDGE.

Post-Tertiary (*Geol.*) A term somewhat ambiguous in its application; but it is most commonly understood to refer to the geological period which succeeded the Late Pliocene. It thus embraces the whole of the Age of Snow (or Glacial Period) and all the time since. Its chronological value in terms of centuries may be gathered from the fact that nearly the whole of Etna, 11,000 ft. high, has grown up in that time, and that, too, at a rate which has been estimated at 1 ft. in three hundred years.

Pot (*Met.*) A general term for a crucible.

Pot Arch (*Glass Manufac.*) A small kiln or furnace in which the pots are burnt previous to being transferred to the melting furnace.

Potash (*Chem.*) A name rather inexactly used to indicate either potassium hydroxide or potassium carbonate; the context generally enables one to tell which compound is meant. It is rarely, if ever, used in scientific chemistry.

Potash Alum (*Chem.*) *See* ALUM.

Potash Mica (*Min.*) A synonym for Muscovite (*q.v.*)

Potassium (*Chem.*) K. Atomic weight, 39·2. Shining bluish white metal; crystallises in octahedra; melts at 62·5°; boils at 667°, giving a green vapour with characteristic absorption spectrum; specific gravity, 0·875 at 13°. The molecular weight determined by the lowering of the vapour pressure in mercury solution indicates a monatomic molecule; value obtained 30 instead of 39. It dissolves in liquid ammonia, forming a blue solution containing the compound potass-ammonium, $K_2N_2H_6$. It is not oxidised in perfectly dry air or oxygen; but in presence of moisture it is almost instantly oxidised. Burns with a violet flame on heating in air or oxygen. Decomposes water at the ordinary temperature, evolving so much heat that the hydrogen liberated is ignited and burns with a flame coloured violet by vapour of the metal, $2K + 2H_2O = 2KOH + H_2$. It forms an amalgam with sodium, which is liquid at the ordinary temperature and has the appearance of mercury. This amalgam is used in making thermometers which will indicate a higher temperature than the boiling point of mercury. Potassium occurs in many silicates; *e.g.* orthoclase (*q.v.*), often called potash felspar: as sylvine, KCl; as carnallite, $KCl.MgCl_2 6H_2O$; as kainite, $K_2SO_4MgSO_4MgCl_2 5H_2O$, all in the Stassfurt deposits: in many mineral springs, and as an essential constituent of the bodies of plants and animals. Potassium was formerly obtained by distilling an intimate mixture of potassium carbonate and charcoal at a very high temperature; but the yield was bad. The method now employed is the electrolysis of fused caustic potash; but, owing to the ease with which potassium catches fire, the kathode must be enclosed. Perfectly dehydrated caustic potash is used; the anode consists of sheet iron, and the kathode of an iron wire (3 mm. thick), which passes through the bottom of a magnesite crucible which is suspended mouth downwards in the melted caustic potash. The crucible is withdrawn by allowing the charge to nearly solidify; then its contents are broken up under naphtha.

Potassium Compounds. POTASSIUM HYDRIDE, KH. Slender white needles; decomposed by water, forming caustic potash and hydrogen; takes fire in oxygen and in chlorine; heated in ammonia gas at 400°, it forms potassamide, KNH_2; it unites with carbon dioxide directly, with quantitative production of potassium formate, much heat being developed, so that cooling may be necessary—$KH + CO_2 = HCOOK$. The hydride is formed by heating potassium in dry hydrogen at 360°. POTASSAMIDE, KNH_2: a white crystalline solid; melts at 273°; sublimes over 400°; decomposed by water into caustic potash and ammonia; with nitrous oxide it yields the potassium salt of azoimide. It is obtained by heating potassium in a silver boat in a current of dry ammonia gas. OXIDES: POTASSIUM MONOXIDE, K_2O, has not been obtained pure. When potassium is melted and the theoretical amount of dry air is brought in contact with it, the product contains unchanged potassium. POTASSIUM PEROXIDE *or* TETROXIDE, K_2O_4, is a yellow solid; gives up oxygen on being strongly heated; behaves as a strong oxidising agent; *e.g.* with sulphur and phosphorus it forms sulphate and phosphate; decomposed by water, forming caustic potash, hydrogen peroxide, and oxygen; with dilute sulphuric acid at a low temperature it is said to form hydrogen tetroxide, H_2O_4 (Ozonic acid). It is obtained by melting potassium in an atmosphere of nitrogen, and then gradually displacing the gas by oxygen, which combines to form the tetroxide. POTASSIUM HYDROXIDE, KOH (often called potassium hydrate and caustic potash). A white brittle solid usually met with in the form of sticks which have been cast; deliquescent, and very soluble in water (2 parts KOH in 1 part H_2O). It is a powerful alkali, uniting with all acids to form salts. On this account it readily absorbs carbon dioxide from the air. It dissolves readily in alcohol, and the alcoholic solution is an important reagent in organic chemistry when it is desired to remove the elements of an acid from an organic compound which would be hydrolysed if aqueous caustic potash were used; *e.g.*

$$\underset{\text{Ethyliodide.}}{C_2H_5I} + KOH = KI + H_2O + \underset{\text{Ethylene.}}{C_2H_4}$$

It is used in making soap. A method of obtaining caustic potash has been described under ALKALI (*q.v.*) Another method, which is worked on a very large scale, is the electrolysis of a solution of potassium chloride in water. The electrolysis is effected by one or other of two methods, each having for its object the prevention of any action of the chlorine which is liberated in the electrolysis on the caustic potash or potassium, as the case may be. The first of these methods is known as the diaphragm process. Several varieties of this process are in use; one of them is as follows: A large iron vessel contains a series of cells made of cement and provided with earthenware covers; between every two cells is suspended an iron plate, and the iron vessel and iron plates are all connected together and form the kathode. The cement cells all stand on insulating porcelain feet, and through the cover of each there passes a carbon rod, a tube reaching nearly to the bottom of the cell, and a delivery tube. All the carbon rods are joined together and form the anode; the long tube serves for charging the cell with potassium chloride; the delivery tube serves for the escape of the chlorine which is used in making bleaching powder. The electrolysis is carried out at 80 to 90°, and it is stopped when the strength of the caustic potash at the anode attains a certain value, beyond which the manufacturer finds it inadvisable to go. Then the kathode liquid is drawn off and concentrated, unchanged chloride separates out, and a very pure product is obtained. The second method is known as the mercury process. Several varieties of this process are in use; one of them, the Castner-Kellner, is as follows: The cell is made of slate, and is divided into three partitions by two slates, all three compartments communicating at the bottom by means of small holes in the partition slates.

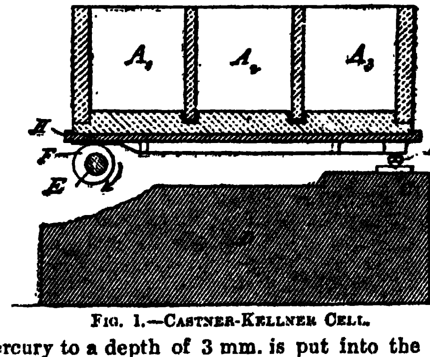


FIG. 1.—CASTNER-KELLNER CELL.

Mercury to a depth of 3 mm. is put into the cell, a solution of the chloride in partitions A_1, A_3 (fig. 1),

and water in partition A_2. The solution is kept about 60°. The anodes are carbon rods placed in the end partitions, and the kathode is an iron plate in the middle partition. Nearly pure chlorine (95 to 97 per cent.) escapes from the end partitions, and the metal alloys with the mercury; the amalgam is brought into the middle partition by rocking the cell, when the metal decomposes the water, forming caustic potash, and the mercury returns to the end partitions. The rocking is effected by resting one end of the cell on an eccentric F, and the other end on a pivot or knife edge B, the eccentric alternately raising and lowering its end of the cell by a distance above and below the horizontal equal to the depth of the mercury in the cell, while the rate of its revolution is such that the mercury has time to acquire its level in each position. When the solution in the middle partition attains a strength of about 25 per cent. caustic potash, it is withdrawn and evaporated. Pure caustic potash may be made on a laboratory scale by heating potassium nitrate with copper foil for several hours to redness in a copper crucible, extracting with water, and evaporating the clear solution in a silver basin. POTASSIUM CHLORIDE, KCl, closely resembles common salt, only it is more soluble in hot water and less soluble in cold water; at 30° the maximum solubility is the same for both, 37 parts in 100 parts water. It melts at 730°. Its occurrence has been mentioned under POTASSIUM (*q.v.*) It is obtained from carnallite by heating it to its melting point (175°), when potassium chloride separates out, and on cooling a further quantity separates, the magnesium chloride remaining dissolved in its water of crystallisation. This salt is used in the preparation of most of the other potassium compounds and also as a manure. POTASSIUM BROMIDE, KBr, is a white solid, crystallising in cubes; melts at 722°; very soluble in water. Largely used in the preparation of silver bromide for photographic purposes, and in medicine in nervous diseases, and as a hypnotic. It is prepared by the action of bromine on iron filings in presence of water, forming a mixture of ferrous and ferric bromides, and decomposing this mixture with potassium carbonate, filtering and crystallising the solution; also by dissolving bromine in a solution of caustic potash, evaporating to dryness, and heating the mixture of bromide and bromate with charcoal. The residue is redissolved, filtered, and crystallised. POTASSIUM IODIDE, KI, closely resembles the bromide in appearance, melts at 685°, and is exceedingly soluble in water. Its solution in water readily dissolves iodine, and from the red solution lustrous black crystals of the tri-iodide, KI_3, separate on evaporation over sulphuric acid. It is largely used in the preparation of other iodides and in medicine. Its preparation is just like that of the bromide. POTASSIUM CHLORATE, $KClO_3$, is a white solid crystallising in shining plates; melts at 359°; at 15°, 100 parts of water dissolve 5 parts of the salt; at 100°, 60 parts. At 372° it begins to give off oxygen, and on continued heating it loses all its oxygen. Traces of chlorine are always evolved in this reaction. If the temperature is kept below that at which potassium perchlorate decomposes, the latter salt is formed as an intermediate product in large amount. On account of the ease with which the chlorate gives up oxygen it is largely used for this purpose. Mixtures of carbon, sulphur, and red phosphorus respectively with the chlorate are easily ignited, and the two latter mixtures explode on percussion; a mixture of antimony sulphide and the chlorate also ignites easily, and this mixture is used in tipping safety matches. With hydrochloric acid, on gentle warming, a mixture of chlorine and chlorine peroxide is evolved, the proportions of the two gases varying with the proportions of chlorate and acid and with the temperature. With sulphuric acid it explodes violently, unless the temperature is kept low; then it forms chloric acid and potassium hydrogen sulphate; on warming, the former decomposes, giving chlorine peroxide and perchloric acid. It is used as an oxidising agent, *e.g.* in the destruction of organic matter in testing for poisons, in the preparation of the dye aniline black, in fireworks, and in making matches; it is also used in medicine. On a small scale it can be made by passing chlorine into a hot and strong solution of potassium hydroxide, $3Cl_2 + 6KOH = 5KCl + KClO_3 + 3H_2O$. On the large scale it is prepared by electrolysis of a solution of potassium chloride; to the solution of chloride a little potassium chromate is added (it appears to form a precipitate of chromium chromate at the kathode, which acts as a diaphragm); the temperature is kept at 60° to 80°; the electrodes are of platinum, or the kathode may be of nickel, and the liquid must be kept stirred all the time. The mixture of chloride and chlorate obtained, in both cases, can be separated by taking advantage of the fact that the chlorate is more soluble in water than the chloride above 95°, while the reverse is the case below 95°. Also, potassium chlorate is less soluble the more chloride there is in solution; *e.g.* at 20° with 50 grs. chloride per litre the solubility of the chlorate is 36·5 grs. per litre, while with 180 grs. per litre of chloride the solubility of the chlorate is 20 grs. per litre: more than 180 grs. per litre of chloride at 20° does not affect the solubility of the chlorate. POTASSIUM CARBONATE, K_2CO_3, is a white, indistinctly crystalline solid; melts at 879°, with some decomposition; very soluble in water (100 parts water dissolve 112 parts carbonate at 20°); deliquescent. Its solution is strongly alkaline, owing to hydrolysis. On the small scale it can be obtained by passing carbon dioxide into one half of a given solution of caustic potash till it is saturated, and then adding the other half: $KOH + CO_2 = KHCO_3$: $KHCO_3 + KOH = K_2CO_3 + H_2O$. Its manufacture has been described under alkali (*q.v.*) It is largely used in the manufacture of other potassium compounds. POTASSIUM HYDROGEN CARBONATE, $KHCO_3$, also called bicarbonate of potash, is a white crystalline solid; decomposes at 190° into carbon dioxide and potassium carbonate; less soluble in water than the carbonate (100 parts of water dissolve 33·2 parts at 20°); its solution decomposes on boiling in the same way as the dry salt on heating. It is obtained by saturating either a solution of the carbonate or of the hydroxide by carbon dioxide. It is used in medicine, *e.g.* in dyspepsia and in gout. POTASSIUM PERCARBONATE, $K_2C_2O_6$, a bluish white amorphous powder; easily decomposed on heating, $K_2C_2O_6 = K_2CO_3 + CO_2 + O$; soluble in water at 0°, but decomposed by water at the ordinary temperature, $K_2C_2O_6 + H_2O = 2KHCO_3 + O$; with acids and alkalis it gives hydrogen peroxide. It oxidises in much the same way as hydrogen peroxide; thus it oxidises lead sulphide to sulphate, and liberates iodine from potassium iodide at 0°; with peroxides oxygen is evolved: $MnO_2 + K_2C_2O_6 = MnCO_3 + K_2CO_3 + O_2$. It is prepared by electrolysing a saturated solution of potassium carbonate at −10° to −15°, when it separates as a bluish solid; it must be quickly filtered off and dried on a porous plate in a stream of dry air: it is never free from

carbonate and bicarbonate. POTASSIUM CYANIDE, KCN, a white crystalline solid, but usually met with cast in sticks; very soluble in water; sparingly soluble in cold alcohol; more soluble in hot alcohol, from which it can be crystallised; very poisonous. It is a powerful reducing agent, so that when heated with metallic oxides it reduces many of them, *e.g.* the oxides of lead, tin, etc., $Pb_3O_4 + 4KCN = 3Pb + 4KCNO$; on this account it is used in blowpipe analysis. When heated with sulphur it unites directly, forming potassium sulphocyanate. In aqueous solution it is hydrolysed, $KCN + H_2O = KOH + HCN$, so that the solution is alkaline, smells of prussic acid, and is as poisonous as this acid, and is slowly hydrolysed to formic acid (potassium formate), $HCN + 2H_2O = HCOOH + NH_3$. With strong sulphuric acid it gives carbon monoxide—no doubt from formic acid produced in hydrolysis of the first liberated hydrocyanic acid. All dilute acids decompose it, liberating prussic acid. Its aqueous solution dissolves platinum, and its dilute aqueous solution with access of air dissolves gold. *See* GOLD. Its solution dissolves many cyanides which are insoluble in water; hence its use in preparing the solutions used in the electrolytic deposition of silver and gold. It is obtained by heating potassium carbonate and carbon at a very high temperature in a stream of nitrogen or of ammonia: in the former gas the heating is done in an electric furnace with carbon electrodes; in the latter the temperature is only 900°, but the ammonia is compressed to one and a third atmospheres. A mixture of sodium and potassium cyanides, which serves the same purposes as potassium cyanide, is made by heating potassium ferrocyanide (anhydrous) with sodium, $K_4Fe(CN)_6 + 2Na = 4KCN + 2NaCN + Fe$. To obtain pure potassium cyanide the vapour of prussic acid is passed into an alcoholic solution of caustic potash—the pure salt separates out. POTASSIUM FERROCYANIDE, $K_4Fe(CN)_6$, is a white solid. Ordinarily the salt is met with in yellow crystals, which contain $3H_2O$; in this form it is commonly called Yellow Prussiate of Potash. It is soluble in water. On heating it alone it gives potassium cyanide, $K_4Fe(CN)_6 = 4KCN + Fe + C_2 + N_2$; on heating with potassium carbonate it gives a mixture of cyanide and cyanate. Heated with concentrated sulphuric acid it yields pure carbon monoxide; with dilute sulphuric acid it yields hydrocyanic acid. Its solution is oxidised by chlorine or bromine to potassium ferricyanide. For the action of nitric acid *see* SODIUM NITROPRUSSIDE *under* SODIUM COMPOUNDS. It is used in the manufacture of Prussian Blue and in calico printing. It is formed by the solution of iron in potassium cyanide solution in absence of air, or of a ferrous salt in the same solution, the latter being in excess. The chief commercial source of this compound is crude coal gas, from which it is prepared in two distinct ways: (1) From the gas before it enters the purifier (*see* GAS MANUFACTURE, p. 250); (2) from the spent hydrated oxide of iron used in some gasworks as the purifying agent. In this case the spent oxide, after a preliminary treatment for the removal of ammonia and sulphur, is mixed with quicklime and heated at 60° to 100° in closed vessels, where it loses ammonia. The product is extracted with water, and the solution of calcium ferrocyanide is treated with sufficient potassium chloride to give the sparingly soluble double salt $K_2CaFe(CN)_6$, which is filtered off, washed, and boiled with potassium carbonate. The solution of potassium ferrocyanide is then crystallised. POTASSIUM FERRICYANIDE, $K_3Fe(CN)_6$ (also called Red Prussiate of Potash), is a dark red solid, crystallising in prisms; heated in air, it gives potassium cyanide and ferric oxide, with loss of cyanogen; soluble in water. Its solution is decomposed by light, forming the ferrocyanide and a blue precipitate; its solution is used as an oxidising agent, being reduced to ferrocyanide, and as a test for iron. It is prepared by passing chlorine into a solution of potassium ferrocyanide, and crystallising till free from potassium chloride. POTASSIUM SULPHOCYANATE, KCNS (also called Potassium Thiocyanate), is a colourless, crystalline, deliquescent solid, very soluble in water, soluble in alcohol. It yields a blood red coloration with solutions of ferric salts. Heated with alkyl iodides, it gives alkyl sulphocyanates. With oxidising agents such as nitric acid, chlorine, etc., it yields a yellow solid of doubtful composition called pseudo-cyanogen sulphide, $C_3N_3S_3H$, which has been used as a dye under the name Canarine. It is prepared by warming a solution of potassium cyanide with sulphur; also by fusing together potassium ferrocyanide, potassium carbonate, and sulphur. The cold and powdered product is extracted by boiling with alcohol; from the alcoholic solution the salt crystallises out. POTASSIUM NITRITE, KNO_2, is a faintly yellow crystalline (prisms) solid; deliquescent; exceedingly soluble in water (dissolves in one-third its weight of water); solution is yellow and slightly alkaline; readily decomposed by acids, giving nitrous acid (*q.v.*) It is obtained by fusing potassium nitrate at a dull red heat, and gradually adding lead, extracting the fused mass with water, and purifying by recrystallisation. A purer product is obtained by passing the red fumes from nitric acid and arsenious oxide into a solution of pure caustic potash till nearly neutral; the nitrite can be crystallised by concentration to the requisite strength. POTASSIUM NITRATE, KNO_3 (also called Salpetre and Nitre), is a white solid crystallising in rhombic prisms; melts at 352°; very soluble in water (at 20°, 100 parts water dissolve 31·2 parts KNO_3). On heating above its melting point it loses oxygen, forming the nitrite, and at higher temperatures it loses nitrogen and forms a mixture of the oxides. It is reduced to ammonia by the action of the zinc-copper couple on its solution. Heated with oxidisable substances, it gives up oxygen to them; *e.g.* sulphur thrown into the fused salt burns brilliantly, so too carbon: $2KNO_3 + 2S = K_2SO_4 + SO_2 + N_2$. $4KNO_3 + 5C = 2K_2CO_3 + 3CO_2 + 2N_2$. *See also* POTASSIUM NITRITE *and* GUNPOWDER. It occurs naturally in rich soils, in most spring and river waters, as an efflorescence on the soil in many hot countries. Formerly the chief source of nitre was the natural product formed by nitrification (*q.v.*) in the soil about the drains of Indian villages. On the large scale it is made by double decomposition between potassium chloride and sodium nitrate. The diagram (fig. 2) shows the solubility of potassium nitrate and sodium chloride expressed in parts dissolved by 100 parts of water. Above 24° sodium chloride is the least soluble in water of any of the four salts mentioned. Below this temperature potassium nitrate is the least soluble. Hence, if hot and strong solutions of sodium nitrate and potassium chloride are mixed, sodium chloride will separate. Below about 24° potassium nitrate will separate; it does not separate pure, but is easily purified by recrystallising. Nitre is used in making gunpowder, in medicine (*e.g.* in asthma, when porous paper is soaked in the solution, dried, and ignited, and the fumes are inhaled), and

as a food preservative. *See also* NITRIC ACID *and* POTASSIUM SULPHIDES. The normal sulphide, K_2S, has not been obtained pure; crystals of K_2S5H_2O are obtained by evaporating the solution obtained by passing sulphuretted hydrogen to saturation into one half of a solution of caustic potash, and then adding the other half. Its solution does not keep, but forms polysulphides and potassium thiosulphate. LIVER OF SULPHUR is the name given to

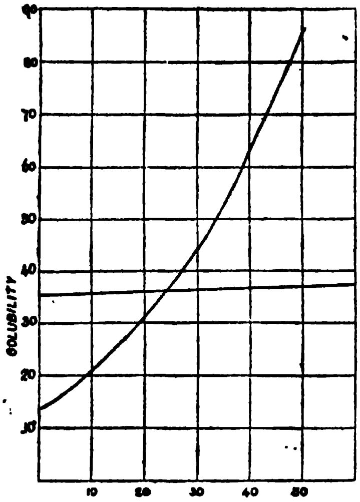
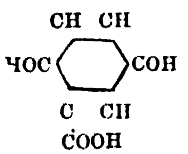
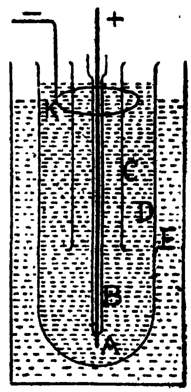


FIG. 2.—TEMPERATURE.

the mixture of sulphides, sulphate, and thiosulphate obtained by heating sulphur and potassium carbonate together. It is used in medicine as an ointment in some skin diseases. The HYDROSULPHIDE, KSH, is obtained by heating potassium in sulphuretted hydrogen, or by saturating a solution of caustic potash with sulphuretted hydrogen. *See* MERCAPTANS. POTASSIUM SULPHATE, K_2SO_4, crystallises in white rhombic pyramids; melts at 1,078°; soluble in water; at 15° 100 parts water dissolve 10·3 parts; insoluble in alcohol. It is used in medicine. It may be obtained by the action of sulphuric acid on the hydroxide, carbonate, or chloride; it is obtained in quantity from Kainite, $K_2SO_4 . MgSO_4 . MgCl_2 5H_2O$, by allowing it to deliquesce when the magnesium chloride goes into solution and the potassium sulphate is obtained by crystallising the residue. POTASSIUM PERSULPHATE, $K_2S_2O_8$, is a white solid which crystallises in tables or prisms; soluble in water (100 parts water dissolve 1·77 parts of the salt at 0°); the solution slowly decomposes on standing in the cold, but quickly on warming, with evolution of oxygen. On heating it begins to decompose at 100°: $K_2S_2O_8 = K_2SO_4 + SO_3 + O$. It is a slow but powerful oxidising agent; it liberates halogen from haloid salts; dissolves many metals, forming sulphates, and then changes the sulphate to peroxide in the case of those metals that form peroxides, *e.g.* silver gives Ag_2O_2, nickel gives Ni_2O_3. It oxidises ferrous sulphate to ferric sulphate; manganous sulphate to manganese dioxide; alcohol to aldehyde; salicylic acid to hydroquinone carboxylic acid,

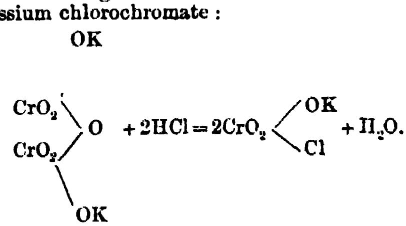


It is obtained by the electrolysis of a saturated solution of potassium sulphate in sulphuric acid of 1·2 to 1·3 specific gravity. The electrodes are of platinum wire: the anode A is sunk deep in the liquid and sealed into a glass tube B for the greater part of its length (high current density at anode): the kathode K is a ring of wire near the surface of the liquid. A wide glass tube C surrounding the anode carries the liberated oxygen to the surface of the liquid without its coming near the kathode. The electrolytic cell D must be cooled by standing in a vessel of cold water, E. The persulphate separates at the anode, and may be purified by adding it to hot water and allowing to cool when the salt crystallises out. Its formation may be represented thus: The negative ions of the acid sulphate travel to the anode, and these (*a*) decompose water, liberating oxygen and reproducing acid sulphate; (*b*) unite with one another to form the persulphate

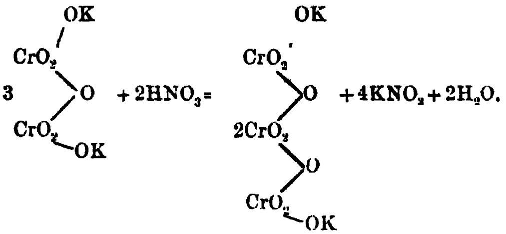


$$SO_2\left\langle{}^{\bar{O}K}_{O-}\right. + SO_2\left\langle{}^{OK}_{O-}\right. = SO_2\left\langle{}^{OKKO}_{O\text{——}O}\right\rangle SO_2.$$

POTASSIUM CHROMATE, K_2CrO_4, is a bright yellow crystalline solid, isomorphous with the sulphate; on heating it melts without decomposition; very soluble in water (100 parts water at 20° dissolve 62·94 parts of the salt); its solution is alkaline to litmus, and has very strong colouring power, one part of the salt colouring 400,000 parts of water; insoluble in alcohol. All acids convert the normal chromate to the dichromate, *e.g.* $2K_2CrO_4 + H_2SO_4 = K_2Cr_2O_7 + K_2SO_4 + H_2O$. It is used as an indicator (*q.v.*) in the estimation of silver. It is obtained by adding the requisite quantity of caustic potash to a solution of the dichromate, $K_2Cr_2O_7 + 2KOH = 2K_2CrO_4 + H_2O$. POTASSIUM DICHROMATE, $K_2Cr_2O_7$, is a red crystalline solid, and the crystals are anhydrous; soluble in water (100 parts water at 20° dissolve 13·8 parts of the salt); insoluble in alcohol; poisonous; on heating, it melts, and only decomposes at a very high temperature into the normal chromate, chromic oxide, and oxygen, $2K_2Cr_2O_7 = 2K_2CrO_4 + Cr_2O_3 + 3O$. Its solution has an acid reaction. Heated with sulphuric acid, the dichromate reacts thus: $K_2Cr_2O_7 + 4H_2SO_4 = K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3O$. This reaction often occurs in the cold, when the solution of dichromate is mixed with sulphuric acid in presence of a substance capable of uniting with the oxygen; hence the use of potassium dichromate in the "Bichromate" battery and in the volumetric estimation of iron, in the oxidation of alcohol to aldehyde, of anthracene to anthraquinone, etc. Heated with concentrated hydrochloric acid, the dichromate gives chlorine: $K_2Cr_2O_7 + 14HCl = 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$. Gentle warming with a less concentrated acid gives potassium chlorochromate:



Heated with nitric acid, it gives the tri- or tetra-chromate, according to the strength of the acid.



Pot. Trichromate.

When gelatine is dissolved in a solution of the dichromate and allowed to solidify again, it is acted on by light, and the dichromate is reduced to chromic oxide; on this fact is based the autotype process of reproducing photographs, etc. Potassium dichromate is made by roasting chrome iron ore, grinding the roasted product, mixing it with potassium carbonate and quicklime, and heating the mixture strongly with free access of air in a reverberatory furnace. $Cr_2O_3 + 2K_2CO_3 + 3O = 2K_2CrO_4 + 2\,CO_2 . Cr_2O_3 + 2CaO + 3O = 2CaCrO_4$. The mixture of potassium and calcium chromates is extracted with water, and sufficient potassium sulphate added to precipitate the calcium as sulphate. The clear liquid is now treated with the requisite amount of diluted sulphuric acid, to convert all the chromate to dichromate, when the latter, being less soluble than the former, largely crystallises out. It is nearly pure. POTASSIUM COBALTINITRITE, $K_3Co(NO_2)_6$, is a yellow, finely divided crystalline solid, sparingly soluble in water. It may be formed by adding potassium nitrite to a solution of cobalt nitrate acidified with acetic acid. As the corresponding sodium salt is very soluble, it may be prepared first as just mentioned, using sodium nitrite in place of potassium nitrite, and then the potassium salt may be made from it by precipitation. The formation of potassium cobaltinitrite in this way serves as a test for potassium, which is far more delicate than platinic chloride. Nickel does not form a corresponding salt; its formation serves to distinguish between cobalt and nickel. For the following compounds, CHLOROPLATINATE, *etc.*, PERMANGANATE, *etc.*, *and* SILICOFLUORIDE, *see under* PLATINUM, MANGANESE, *and* SILICON COMPOUNDS *respectively*.

Potato (*Botany*). The underground stem tubers of the plant *Solanum tuberosum* (order, *Solanaceæ*) constitute the well known potatoes.

Potato Stone (*Geol.*) Geodes with a rough exterior which bears some resemblance in texture, and even in colour and size, to the vegetable from which the name is taken. They occur chiefly in the "Dolomitic Conglomerate" (which is a breccia of Upper New Red age) near Bristol.

Potboard (*Carp. and Join.*) The shelf under the drawers of a dresser.

Potboiler (*Art*). A work of art of little merit produced to fill a popular demand.

Potcher (*Paper Manufac.*) A machine similar in construction to the "breaker," used for breaking and bleaching pulp.

Potent (*Her.*) An obsolete word signifying a crutch. A field covered with small figures resembling a cross without the upper arm is called potent. Like vair, the tinctures are argent and azure alternately. *See* HERALDRY.

Potential Difference (*Elect.*) The difference of potential between two points is equal to the amount of work which must be done on a positive unit of electricity in order to bring it from one point to the other. In practice it is usually measured in VOLTS (*q.v.*) In the case of a battery, dynamo, etc., the potential difference at the terminals is that portion of the total electromotive force which is available for sending a current round any circuit external to the source itself.

Potential, Electrical. The work which must be done (against electrical forces) on a unit positive charge, in order to bring it up to a given point from an infinite distance (or from a place at which the potential is zero) is termed the Electrical Potential at that point. The potential V, due to a charge Q, at a distance r from the charge, is $V = \frac{Q}{r}$.

Potential Energy. The energy which a body possesses in virtue of its position, chemical constitution, or circumstances other than its state of motion. *Cf.* KINETIC ENERGY.

Potential Gradient (*Elect.*) The ratio between the difference of potential at two points in a conductor to the distance between the points measured along the conductor.

Potential, Magnetic. The work which must be done (against magnetic forces) in order to bring a unit positive pole up to a given point from an infinite distance, or from a place where the potential is zero, is termed the Magnetic Potential at that point.

Potentiometer (*Elect.*) An instrument for the comparison of electromotive forces by balancing them against the potential difference between two points in a conductor of considerable resistance, through which a steady current is flowing.

Pot Metal (*Met.*) An alloy of copper and lead, with sometimes tin, zinc, etc., added. It is occasionally used instead of brass in inferior work.

Pot-Pourri (*Music*). A collection or medley of musical tunes.

Pot Sleeper (*Civil Eng.*) A CHAIR (*q.v.*) cast on a broad base instead of being fixed to a wooden sleeper; used where wood is liable to rapid decay or destruction by white ants, etc.

Pott (*Paper*). Writing paper, 15 by 12½ in. Printing paper, 15½ by 12½ in.

Potter's Wheel (*Pottery Manufac.*) A vertical shaft with a flat circular head about 8 in. in diameter, upon which, while rotating at greater or less speed, such circular articles as cups, bowls, flower pots, etc., are made by the "Thrower."

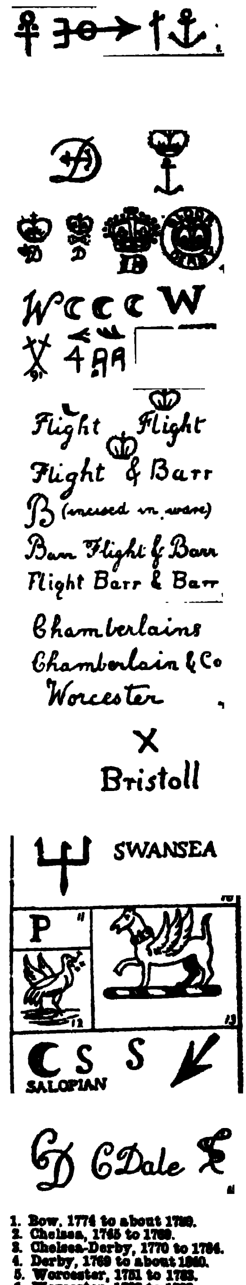
Pottery and Porcelain. (1) *Modern Methods of Manufacture.* (2) *History.*

(1) MODERN METHODS OF MANUFACTURE: Although generally spoken of in the same connection, pottery and porcelain are not synonymous terms. The generic term "Pottery" includes porcelain, terracotta, earthenware, and, in fact, any manufactured article composed of more or less vitrified clay. "POTTERY," properly so called, is inferior to porcelain. It is composed of clays and earths, either simple or admixed, which, after being submitted to the greater or less heat of the kiln, remain of a clay nature—porous, opaque, and only slightly resonant. "PORCELAIN" is more highly refined, and is composed of higher quality clays and earths, silicates, alkalies, phosphates, and alumina. After submission to a

sufficient heat in the kiln, its nature becomes changed, and it is no longer clay; it is highly vitrified, non-porous, semi-translucent, and highly resonant when struck. Porcelain is subdivided into two classes: hard paste and soft paste. "HARD PASTE" is, generally speaking, an admixture of natural materials, such as "kaolin" (a silicate of alumina) and "petuntse," a similar material, but less decomposed, and containing more alkali and more lime. After thorough amalgamation, the article manufactured from the resulting paste is burnt at such a temperature as leaves it only hardened and porous. It is then dipped in the glaze mixture, which is composed largely of felspar, and submitted to a sufficiently high temperature to melt the glaze, which becomes partially absorbed by the "body," rendering it translucent and non-porous, and giving a perfect gloss to its surface. SOFT PASTE is more artificial in its composition than hard paste, and is manufactured on a different principle. Kaolin and petuntse are the chief ingredients, as in hard paste, but to them is added calcined bone and sometimes felspar. The articles manufactured from soft paste are first submitted to the greatest heat, rendering them at the first burning non-porous, translucent, and resonant. They are then dipped in the glaze mixture, which is composed generally of a glass flux, kaolin, and carbonate of lime, ground finely together, and afterwards submitted to a temperature much lower than the first or bisque heat, but sufficient to melt the glaze upon the surface of the ware, the glaze in soft paste remaining upon the surface of the ware, and not being absorbed into it as in hard paste. Apart from the difference in the constituents, the manufacture of pottery and porcelain is almost identical. After the raw materials are reduced to fine creamy consistency either by grinding or by blunging (cutting up of clays in water by rotating knives), they are mixed in their proper proportions, and the resulting paste is then either used in "slip" or creamy state, or in clay, to obtain which a sufficient amount of water is squeezed from the "slip" in presses, or evaporated from it by heat, so rendering it stiff and plastic. The clay is now passed to the "thrower," who makes articles upon the potter's wheel, or to the "presser," who forms them by pressing it upon proper moulds. The "slip," on the other hand, goes to the caster, who forms the required articles by casting; that is, by pouring the "slip" into the moulds. In each case the moulds are made of plaster of paris or gypsum, and are very porous, rapidly absorbing water from the clay or slip placed in contact with them. In the case of casting, the absorption of the plaster mould causes a coating of clay to adhere all over the inside of the mould and take its exact shape, and when this is sufficiently thick the potter pours away the remaining slip from the mould, and in due course the coating becomes sufficiently hard for the mould to be opened, and the clay which has formed inside to be taken out and finished. Articles "thrown" upon the wheel are generally, and while the clay is still moist, pressed into moulds, to ensure uniformity of size and weight. After they have become sufficiently hard to handle, they are removed from the moulds, and are finished by the "turner" upon the lathe. In the case of "handled" pieces, the handle, after being "pressed" in a mould of the required shape, is affixed by dipping the part which is to come in contact with the body in "slip," and pressing it into the the correct position. The manufacture of elaborate figures or VASES is done by casting, each part being formed in a separate mould, and the pieces joined together by the skilled potter. Some figures and vases require as many as from ten to forty moulds for the manufacture of the one perfect piece. An important consideration in the manufacture of pottery and porcelain is the contraction that takes place until the article has reached the maximum heat in the bisque oven. The contraction is threefold, and is due (1) to the evaporation or expulsion of the added water; (2) to the driving off of the chemical water; (3) to the vitrification or drawing closer together of the particles of which the paste is composed. Clay articles when completed and thoroughly dried are placed in SEGGARS or fireclay boxes, plates, saucers, and flat ware being bedded in ground flint, the bed being made by a mould the exact shape of the article to be fixed in it. The seggars containing the clay ware are stacked in the bisque oven, which is bricked up. The fires are lit, and the heat is slowly raised to the required temperature. After cooling, the kiln is opened and the ware taken out, the superfluous ground flint removed by scouring, and the ware sent to the dipping house, where it is dipped in the required glaze. This is of about the consistency of thin cream. The articles are again placed in seggars (glazed), and stacked in the glost or glazing oven, which is generally of similar construction to the bisque oven. Except in the case of hard paste, the heat now necessary is much less than that required for bisque. Upon removal of the glazed ware from the glost oven, it is sorted and is then ready to be decorated. In the case of under glaze decorations, they are applied to the *bisque ware*, the glaze being super-imposed, the melting of the glaze allowing the colours to show through. Reds made from oxides of iron and pinks and purples made from gold will not stand the great heat of the glost oven, and therefore cannot be used as under glaze colours. The glazed ware is now sent to the decorators for the requisite ornamentation. If it is to be painted, it goes first to the painter; if it is to have a coloured ground, to the ground layer (*q.v.*); or if a printed pattern, to the printer. To produce the best results, the painting is usually executed in two and sometimes even three or more stages, the ware being burnt in the enamel kiln (*q.v.*) after each painting. The first coat is called the "washing in," and the subsequent paintings the "finishing." The colours used are made from mineral salts, the following being the main colouring agents: Blues are made from cobalt; blacks from cobalt, manganese and iron in combination; turquoise from oxide of copper; greens from oxide of chrome and from oxide of copper; browns and reds from the chromates and oxides of iron; yellow from lead, tin, and antimony in combination; enamel pinks, rose colours, purples, rubies, and crimsons from gold; under glaze pink from oxides of tin and chrome in combination. Metallic gold, which is laid on as required by the gilder, is fired at the same heat as the painting in the enamel kiln. Gold is prepared as follows: Pure grain gold is obtained, and to it is added a certain proportion of metallic mercury. The mercury forms an amalgam with the gold, destroying its ductility; a little flux is added to ensure its adhesion to the ware, and the mixture is finely ground upon a mill. It is then mixed with a suitable medium, and laid upon the ware with a paint brush; upon being subjected to the heat of the kiln, the mercury becomes volatilised, leaving the pure gold adhering to the ware. The gold is afterwards burnished by being rubbed with an agate or hematite, commonly called bloodstone.

(2) HISTORY: *Ancient Pottery—Egyptian, Greek, Roman.* The history of pottery is practically the history of man. There is no nation in the world in which use has not been made of clay for the formation of vessels for domestic or other purposes. Pottery, with more or less pronounced attempts at decorative ornamentation, has steadily followed the path of civilisation, and amongst historic nations the earliest pottery known is that of Egypt, dating some three thousand years before the Christian era. These relics of the earliest known civilisation have definite characteristics in harmony with the ruins among which they have been found; improvement and development were gradual and persistent, and the later progress of one nation is coeval with the germ of art in another. In the course of a few centuries Egyptians discovered the art of glazing their wares. Subsequent progress is evident as regards style and refinement of form some centuries later, until there is a new birth in another and a neighbouring country, influenced by the developments of a couple of thousand years in the older nation. Thus we see in the first Greek archaic pottery (dating about 700 B.C.) traces of Egyptian civilisation and motives of Egyptian character. From the date of the earliest Greek wares progress becomes much more rapid as civilisation advances, and in a period of about three hundred years we arrive at the most sublime period of Greek Keramic Art. Egyptian character has gradually died away, and has given place to the vigorous indigenous growth which has been grafted upon it. The Greek pottery of this period (about 400 B.C.) is marvellous in its perfection of form and in the care exhibited in the execution of the ornamental delineations. Figures of the most refined and beautiful character were also produced. As from the Egyptian to the Greek, so from the Greek to the Roman; but it cannot be said that the wonderful progress was continued or even the high level maintained. Pottery is essentially one of the arts of peace, and the Romans were not a peaceful people. Roman pottery never attained the perfection of the Greek; the materials were coarser, the forms less refined, and the ideas of decoration were more inclined to revert to the Archaic than to improve upon the Etruscan. Not only were the Romans unable to hand down a pure classic style of their own to future generations, but by their lust of conquest they brought about the extinction of, and dealt the death blow to, the long line of the most sublime creations in Keramic history. PORCELAIN emanates from the Celestial Empire, and was first made about one hundred years B.C. The finest Chinese porcelain was made during the fourteenth, fifteenth, and sixteenth centuries. Porcelain was probably not made in Europe before the end of the seventeenth or the beginning of the eighteenth century. The first porcelain manufactured in England was produced just before the middle of the eighteenth century (about 1740). The chief European manufactories of porcelain, dating from the earliest days, are: Dresden (Meissen), the national manufactory of Saxony, established about 1706, and still flourishing; Capo di Monte (Naples), established 1736, abandoned 1821; Buen Retiro (Madrid), established same time, abandoned 1812; Lille, established 1711, abandoned about 1800; Tournay, established 1750, still carried on; Chantilly, established 1725, abandoned about 1800; St. Cloud, established about 1696, destroyed by fire 1773; Sèvres (originated at St. Cloud), the national manufactory of France, and still carried on (the finest Sèvres porcelain was manufactured about the middle of the eighteenth century); Berlin, established 1751, the national manufactory of Germany, and still flourishing; Vienna, established 1718, practically ceased working about 1860. There have been, of course, many other less important factories, and there are to-day great numbers in France, Germany, and Austria. Pottery has been, and probably is still, made in every country on the globe, and it is difficult to specify places; but mention may be made of Delft in Holland, Rouen (France), Urbino and Faenza (Italy), as producing as early as the end of the fifteenth century exceedingly fine decorated pottery. In England pottery and good earthenwares were made at a very early date, but porcelain is only traceable to the first half of the eighteenth century. The first manufactory of any note was probably that established at Stratford-le-Bow, near London, the productions being always known as "Bow" china. This manufactory only lasted about thirty years, the whole concern being purchased about the year 1770 by William Duesbury, of Derby. A porcelain manufactory was established at Chelsea a little later, and became very famous for its fine productions, large quantities of figures and fine vases being made there. This manufactory was also purchased by Duesbury about the same time or a little earlier (1769) than the purchase of Bow. The next establishment for the manufacture of porcelain was that at Worcester in 1751. It is probable that the productions of no English porcelain manufactory equalled those of Worcester for refined taste and general excellence. The manufactory has been continued to the present day, and it is the only porcelain manufactory in existence in England which can show an unbroken descent from so early a date as 1751. The manufactory at Derby, established in 1756, was continued until the year 1849, and about the

ENGLISH POTTERY MARKS.



1. Bow, 1774 to about 1780.
2. Chelsea, 1745 to 1769.
3. Chelsea-Derby, 1770 to 1784.
4. Derby, 1769 to about 1840.
5. Worcester, 1751 to 1783.
6. Worcester, 1783 to 1792.
   Worcester, 1793 to 1807.
   Worcester, 1793 to 1812.
   Worcester, 1793 to 1812.
   Worcester, 1813 to 1840.
7. Worcester (Chamberlains), 1786 to 1840.
8. Plymouth, 1768 to 1774.
9. Bristol, 1768 to 1782.
10. Swansea, about 1800 to about 1830.
11. Pennington, Liverpool.
12. Herculaneum, Liverpool.
13. Rockingham Porcelain, about 1823.
14. Caughley (Salopian), 1772 to 1799.
15. Coalbrook Dale (Coalport), 1780 to about 1840.

same period were founded factories at Caughley (Salopian), Coalport, and Lowestoft; also the factories at Plymouth and Bristol, and both pottery and porcelain were made in Liverpool. The celebrated Wedgwood ware was also first produced about the same period (1762). At later dates the manufacture of pottery and porcelain extended very considerably, especially in the "Pottery" district of North Staffordshire, there being many factories at Stoke-on-Trent, Hanley, Burslem, Longton, Shelton, etc. Factories which, however, existed for only a comparatively short space of time were carried on at Nantgarw and Swansea, in Wales. The Rockingham manufactory at Swinton also produced some fine porcelain. It is probable that at the present time *pottery* in one form or another is made in nearly every county in England. The manufacture of *porcelain* is much more restricted, being practically confined to Worcester, Derby, Coalport, and the Staffordshire "Potteries." W. M. B.

Pot Valve (*Eng.*) A valve whose cover consists of a short tube closed at the top; occasionally used as a safety valve.

Pouncing (*Dec.*) The method of transferring a design done on paper to a panel, ceiling, wall, or other surface on which it is to be finally executed. It consists in perforating the outline of the design with a needle set in a handle, or, better still, by means of a small implement used by dressmakers, and called a "tracer." The paper pattern is then fixed in position on the wall, etc., by means of needle points, and a pouncer formed of a linen bag, and containing charcoal or fine coloured chalk, is dabbed over the lines, a portion passing through the small holes and leaving the pattern on the surface beneath. When the design is of a complicated character, it is often found convenient to use two or more different coloured chalks, so as to distinguish the different parts.

Pound. *See* WEIGHTS AND MEASURES.

Poundal (*Mech.*) The unit of force in the English system; it is the force which, if it act on a mass of 1 lb., produces in it an acceleration of 1 ft. per second per second.

Pound Degree (*Eng.*) The unit of heat commonly used by English engineers; it is the amount of heat necessary to raise 1 lb. of water 1° F.

Pouring (*Foundry*). The process of filling a mould with melted metal.

Pouring Gate (*Foundry*). The INGATE by which melted metal enters a mould. *See* GATE.

Poussé (*Music*). The upstroke of the bow.

Powder of Algaroth (*Chem.*) An old name for antimony oxychloride, so called from a physician, Algarotus, who employed it in medicine. It is not used now.

Power (*Phys., Eng., etc.*) The amount of work done (or energy supplied) in unit time. *See* HORSE POWER, JOULE, *and* WATT.

——, Alternating Current (*Elect. Eng.*) The power developed by an alternating current is equal to the product of the virtual current, virtual voltage, and the cosine of their phase difference. *See* POWER FACTOR.

——, Electrical. *See* WATT.

Power Factor (*Elect. Eng.*) The ratio of the true power in an alternating current circuit to the apparent power obtained by multiplying together the virtual current C and virtual voltage V. In simple cases the power is equal to CV Cos ϕ, where ϕ is the angle of lag or phase difference between the E.M.F. and the current in the circuit.

Power House (*Elect. Eng., etc.*) The building or central station containing the engines, boilers, dynamos, etc., for supplying current.

Practical Units (*Elect.*) *See* AMPÈRE, VOLT, OHM, *and* UNITS, ELECTRICAL.

Pralltriller (*Music*). *See* MORDENTE.

Prase (*Min.*) A translucent leek-green variety of quartz or chalcedony. It is used as an ornamental stone.

Prasodidymium (*Chem.*) *See* DIDYMIUM.

P. R. B. (*Art*). *See* PRE-RAPHAELITE BROTHERHOOD.

Pre-Admission (*Eng.*) The admission of fresh steam to a cylinder shortly before the end of a stroke.

Pre-Cambrian Rocks (*Geol.*) The series of fossiliferous rocks, which are next older than the Ordovician Rocks, forms the lowest member of the Protozoic System. As the Cambrian Rocks contain representatives of almost all the known groups of invertebrata, they were probably formed long after the Dawn of Life upon the Earth. Three subdivisions of the Cambrian Rocks are recognised. The lowest, sometimes called the Taconic System, contains the trilobites belonging to the *Olenellus* group; the next above yields trilobites of the *Paradoxides* type; and the highest is characterised by forms of trilobites allied to *Olenus*. In the north-west of Scotland the highest member of the Cambrian Rocks is the Durness Limestone. Below the base of the Cambrian Rocks, and therefore of older date than any fossils yet known with certainty, there occur various other rocks, which are those referred to. In the Longmynd, on the border of Wales, the base of the Cambrian Rocks at Caer Caradoc lies upon some ancient volcanic rocks known as the URICONIAN ROCKS, and in another place upon some very ancient sediments. In Anglesea, again, a Pre-Cambrian set of volcanic rocks, the Bangor Beds, underlies the base of the Cambrian Rocks. At Barmouth a thick series of greywackés, the Harlech Beds, usually classed with the Cambrians, occurs beneath them. In the north-west of Scotland an ancient set of rocks, the TORRIDONIANS, which were formed under desert conditions, occurs between the Lewisian Gneiss and the lowest member of the Cambrian Rocks; and if they are not faulted into that position, they must also be truly of Pre-Cambrian age. Elsewhere in Scotland the rocks which are known with certainty to be Pre-Cambrian are either part of the Lewisian Gneiss or else some very ancient sediments, out of which, it is believed, the gneisses themselves have been formed.

Precentor (*Music*). A cathedral official who directs the choir and the musical portions of the service.

Precession of the Equinoxes. A gradual movement of the First Points of Aries and of Libra along the ecliptic, at the rate of about 50 seconds per year. This is due to the fact that the earth's axis is not fixed in space, but is slowly describing a conical figure, like a spinning top does when it "reels" without falling over.

Précieux (*Art*). The term applied to works of art which exhibit careful execution with a fine and masterly touch.

Precious Coral. *See* CORAL.

Precious Stones and Gems. To the ancients a gem was any stone which was beautifully coloured, rare, or of sufficient hardness to use for seal engraving. The term is now used for a stone which in one

small piece exhibits fine colour, fire, or lustre, and which is hard enough to take a good polish. Precious stones are those which possess similar properties in an inferior degree. The nomenclature is very complex, and those minerals to which the ancients applied a certain name are in but few cases the same as those for which we now use the name. In popular language many totally different minerals are known by the same name; and lapidaries name a gem stone rather by its colour than by its composition, distinguishing between different species by calling the more valuable Oriental and the less valuable Occidental. Often, too, they use some adjective derived from the locality in which the stone occurs to indicate the less or more valuable gems, *e.g.* yellow Quartz they call Brazilian Topaz to distinguish it from true Topaz; and the yellow variety of Corundum, which is more valuable on account of rarity, hardness, and brilliancy than the true Topaz they call Oriental Topaz. Another confusion arises from the popular impression that many gems which are of the same mineralogical species are different, *e.g.* Ruby and Sapphire, which are both varieties of Corundum.

LIST I.—COMMERCIAL AND POPULAR NAMES.—In this list, against the popular name of the gem, is given a note of the various minerals which may occur commercially under that name.

ADAMANT	Diamond.	
	Corundum in part.	
ALABASTER	of the Ancients	= a stalagmitic variety of Calcite.
	massive Gypsum.	
ALMANDINE	one of the Precious Garnets.	
	an old name for violet Spinel.	
AMETHYST	true	= violet Quartz.
	Oriental	= violet Corundum.
	false	= violet Fluorspar.
	in part the Hyacinth of the ancients.	
AVENTURINE	a variety of Quartz with spangles of Mica.	
	a variety of Orthoclase with spangles of Mica.	
	a variety of Albite with spangles of Mica.	
	a variety of Oligoclase with spangles of Mica.	
BERYL	*See* LIST II.	
CAT'S EYE	Quartz with parallel fibres of Asbestos.	
	Chrysoberyl cut *en cabochon.*	
	a variety of Microcline.	
CHRYSOBERYL	true	
	of the Ancients	yellow green Beryl in part.
		Chrysoprase in part.
CHRYSOLITE or PERIDOT	true, a variety of Olivine.	
	Oriental	= yellow green Corundum.
	of the Ancients	= Topaz.
	Brazilian	= yellow green Tourmaline.
	Peridot of Ceylon	= yellow green Tourmaline.
CHRYSOPRASE	true, a green variety of Chalcedony.	
	of the Ancients	= Emerald.
		Chrysoberyl.
DIAMOND	true.	
	Occidental	= Rock Crystal, a variety of Quartz.
EMERALD	true, green Beryl.	
	false	= green Fluor.
	Oriental	= olive green Corundum.
	Brazilian	= green Tourmaline.
GARNET	*See* LIST II.	
HYACINTH or JACINTH	true, a red variety of Zircon.	
	Oriental	= reddish brown Corundum.
	of Compostella	= Quartz stained red by clay.
	Vesuvian	= Idocrase.
MOONSTONE	a variety of Microcline, Albite, or Oligoclase.	
	of the Ancients	= Selinite, a variety of Gypsum.
PERIDOT	*See* CHRYSOLITE.	
RUBY	true or Oriental	= Corundum of the ruby colour.
	false	= red Fluor.
	Bohemian	= rose Quartz.
	Balas Ruby	= red Spinel.
	Elie Ruby, Rock Ruby	= Pyrope Garnet.
	Brazilian	= yellow Topaz turned red by heat.
		red Tourmaline.

SAPPHIRE	true or Oriental . .	blue Corundum (= Telesia).
	false	blue Fluor. blue Quartz.
	Saphir d'Eau Water Sapphire . .	= blue Iolite.
	of the Ancients in part .	= Lapis Lazuli.
	Brazilian	= blue Topaz. Indicolite (blue Tourmaline).
	Sapphire of de Saussure.	= Cyanite.
SPINEL	*See* LIST II.	
TOPAZ	true	
	false	= yellow Fluor. Citrine (yellow Quartz).
	yellow Bohemian	= Citrine (yellow Quartz).
	smoky	= Smoky Quartz.
	Oriental	= reddish yellow Corundum.
	of Ancients	= Olivine in part.
TURQUOISE	true.	
	of Ancients	= Lapis Lazuli in part.

LIST II.—NAMES OF MINERALOGICAL SPECIES.—In the following list of gems and precious stones the names as commonly used are given under the *mineralogical species* to which the stones belong; those marked with an asterisk may more properly be considered gems.

*DIAMOND = Adamant of the Ancients.

FLUORSPAR: the violet variety . = False Amethyst.
- „ green „ . = „ Emerald.
- „ red „ . = „ Ruby.
- „ blue „ . = „ Sapphire.
- „ yellow „ . = „ Topaz.

QUARTZ.—Varieties: Rock Crystal . = Occidental Diamond = Whitestone.
- Stained red by clay = Hyacinth Compostella.
- Star Quartz.
- *Amethyst: this was in part the Hyacinth of the Ancients.
- Rose Quartz . . = Bohemian Ruby.
- *Citrine . . . = Yellow Topaz = False Topaz = Bohemian Topaz.
- *Smoky Quartz. . = Cairngorm = Smoky Topaz. Morion is a very dark variety.
- Blue . . . . = Sapphire.
- Aventurine.
- Sagenitic: (*a*) containing Rutile = Venus' or Thetis' Hair Stone or Flêches d'Amour.
- Cat's Eye. Tiger's Eye. Chalcedony.
- Carnelian . . . = Sard; finer varieties = Oriental Carnelian; softer and yellowish red varieties = Occidental Carnelian.
- Chrysoprase . . = Chrysoberyl of the Ancients.
- Prase . . . . = A leek green variety.
- Plasma, from πλάσμα, is used for intaglios.
- Bloodstone . . = Heliotrope.
- Agate: (*a*) Banded . = Scotch Pebble; (*b*) Fortification; (*c*) Moss Agate = Mocha Stone.
- Onyx, naturally bands of different degrees of porosity. Only black and white artificially.
- Sardonyx = bands of Sard (Carnelian) and white Chalcedony.
- Jasper.

OPAL.—Varieties are: Precious Opal, Fire Opal, Australian Opal, Cacholong (a milky white variety), and Girasol, white with red reflections in the sun.

CORUNDUM: anciently Corivendum, sometimes called Adamant.

Varieties in colour:
- pigeon's blood . = *Ruby (also called Oriental or True Ruby).
- magenta . . = Barklyite.
- reddish brown . = Oriental Hyacinth.
- light brown . = Adamantine Spar.
- violet . . = Oriental Amethyst.
- with pearly reflections = Chatoyant / Opalescent Sapphire.
- white .
- reddish yellow = Oriental Topaz.
- colourless
- yellow green = Oriental Peridot or Oriental Chrysolite.
- olive green = Oriental Emerald.
- blue . . = *Sapphire (also called Oriental Sapphire and Telesia). Sub-variety: Asteriated or Star Sapphire or Star Stone. Sapphire was in part the Hyacinth of the Ancients.
- different colours Montana Sapphire.
- colourless, with reddish or bluish reflections = Girasol Sapphire.

SPINEL: red . . . . = *Balas Ruby (Rubicelle or Ruby Spinel).
pale blue . . . . . . = Akcrite.
violet . . . . = Almandine of old writers.
*CHRYSOBERYL.—Varieties: Alexandrite, dark emerald green, red by transmitted light, strongly phosphorescent.
Cat's Eye . = Cut *en cabochon.*
Cymophane, an opalescent variety.
Chrysoberyl represented in part the Chrysoprase of the Ancients.
CALCITE.—Varieties: Mexican Onyx, stalactitic, from Mexico.
Alabaster of the Ancients was a stalactitic or stalagmitic calcite.
Lumachelle or Fire Marble.
MALACHITE.
ORTHOCLASE: Adularia, a transparent and pearly variety.
Sunstone or Aventurine Felspar containing spangles of Mica.
MICROCLINE: Moonstone, with a pale pearly lustre.
Amazonstone, bright green.
Cat's Eye, with a banded flash of light.
ALBITE: Aventurine (Sunstone).
Moonstone.
OLIGOCLASE: Sunstone.
Moonstone.
LABRADORITE.
PYROXENE: Diopside, a green transparent variety from Ala in Piedmont.
CROCIDOLITE.
*BERYL: pale green . = *Beryl of jewellers.
blue green . = Aquamarine.
yellow green . = Golden Beryl, the Chrysoberyl of the Ancients.
rich green . = *Emerald, formerly Smaragd; the Chrysoprase of the Ancients.
*IOLITE . = *Cordierite = Dichroite.
Saphir d'Eau or Water Sapphire is a blue variety.
LAPIS LAZULI . . . . . = Sapphire of Ancients in part. Turquoise of Ancients in part.
GARNET: I. Aluminium Garnet . = Grossularite (*Essonite).
*Pyrope (Precious Garnet, Ruby, Bohemian Garnet, or Rock Ruby).
*Almandine = Precious Garnet in part (*en cabochon* = Carbuncle).
II. Iron Garnet . . = Topazolite, a yellow variety.
Dermantoid, an emerald green variety.
III. Chromium Garnet . = Uvarovite, green.
OLIVINE: *Chrysolite (Peridot, the Topaz of the Ancients) is a yellow green transparent variety.
Chrysopal is an opalescent variety.
DIOPTASE.
IDOCRASE . . . . . = Vesuvianite = Vesuvian Hyacinth. Cyprine is a pale blue variety.
ZIRCON: red . . . . = *Hyacinth or Jacinth (the Legiero of Aaron's Breastplate probably).
colourless or smoky . = Jargoon.
olive green . . . = Beccarite.
*TOPAZ . . . . . . = Chrysolite of the Ancients; formerly also called Physalite or Pyrophysalith.
colours: pale yellow . . = Saxon Topaz (when turned red by heat it is called Brazilian Ruby).
more varied yellows . . = Mexican Topaz.
colourless . . . . . = Gouttes d'Eau.
blue . . . . . . = Brazilian Sapphire.
ANDALUSITE.
*CYANITE . . . . Sapphire of de Saussure; also called Sapparc.
ZOISITE: a pink variety is called Thulite.
PREHNITE: cut *en cabochon.*
*TOURMALINE: colours: dark blue . . = Indicolite or Brazilian Sapphire.
yellow green . = Peridot of Ceylon or Brazilian Chrysolite.
pink . . = *Rubellite or Red Schorl.
red . . . . = Brazilian Ruby.
green . . = Brazilian Emerald.
colourless . . = Achroite.
SERPENTINE.—Varieties: Precious Serpentine and Picrolite (fibrous).
SPHENE: Ligurite, a green variety from Liguria.
TURQUOISE . . . . = Callais of Pliny.
GYPSUM: the variety Selenite probably was the Moonstone of the Ancients; massive = Alabaster.
AMBER: Copalite is a fossil Amber.
JET.

List III.—The following table gives the crystallographic system, chemical composition, and principal physical characteristics of the species enumerated above:

	Crystallographic System.	Specific Gravity.	Hardness.	Refractive Index.	Chemical Formula.
Diamond	Cubic	3·5—3·6	10·0	2·439	C
Fluorspar	Cubic	3·017—3·188	4·0	1·434	CaF_2
Quartz	Rhombohedral	2·5—2·8	7·0	1·548	SiO_2
Opal	(Amorphous)	1·9—2·3	5·5—6·5		$SiO_2 . NH_2O$
Corundum	Rhombohedral	3·93—4·08	9·0	1·794	Al_2O_3
Spinel	Cubic	3·52—3·95	7·5—8·0		$MgO . Al_2O_3$
Chrysoberyl	Orthorhombic	3·68—3·75	8·5	1·76	$BeO . Al_2O_3$
Calcite	Rhombohedral	2·69—2·75	3·0	1·654	$CaCO_3$
Malachite	Monosymmetric	3·71—4·01	3·5—4·0		$2CuO . CO_2 . H_2O$
Orthoclase	Monosymmetric	2·53—2·59	6·0	1·53—1·76	$K_2O . Al_2O_3 . 6SiO_2$
Microcline	Triclinic	2·44	6·0		$K_2O . Al_2O_3 . 6SiO_2$
Albite	Triclinic	2·54—2·64	6·0—6·5		$Na_2O . Al_2O_3 . 6SiO_2$
Oligoclase	Triclinic	2·63—2·74	6·0		$3(Na_2O . Al_2O_3 . 6SiO$
Labradorite	Triclinic	2·67—2·76	6·0		$Na_2O . Al_2O_3 . 6SiO_2$
Pyroxene	Monosymmetric	3·2—3·4	5—6	1·680	$CaO(Fe,Mg)O . 2Si$
Crocidolite	(Fibrous)	3·2—3·3	4·0—4·5		$NaFe(SiO_3)_2 . FeSiO_3$
Beryl	Hexagonal	2·67—2·75	7·5—8·0	1·585	$3BeO . Al_2O_3 . 6SiO_2$
Iolite	Orthorhombic	2·60—2·72	7·0—7·5	1·544	$H_2O . 4(MgFeO) . 4Al_2O_3 . 10SiO_2$
Lapis Lazuli	Cubic	2·38—2·45	5·0—5·5		$Na_4(NaS_3 . Al)Al_2Si_3O_{12}$
Garnet—					
I. Aluminium:					
(*a*) Grossularite	Cubic	3·44—3·62	6·5—7·0		$6CaO . 3SiO_2 + 2Al_2O_3 . 3SiO_2$
(*b*) Pyrope	Cubic	3·70—3·78	6·5—7·5	1·792	$6MgO . 3SiO_2 + 2Al_2O_3 . 3SiO_2$
(*c*) Almandine	Cubic	3·95—4·29	7·0—7·5		$6FeO . 3SiO_2 + 2Al_2O_3 . 3SiO_2$
II. Iron:					
(*a*) Topazolite (*b*) Dermantoid	Cubic	3·65—3·85	7·0		$6CaO . 3SiO_2 + 2Fe_2O_3 . 3SiO_2$
III. Chromium:					
(*a*) Uvarovite	Cubic	3·42	7·5—8·0		$6CaO . 3SiO_2 + 2Cr_2O_3 . 3SiO_2$
Olivine	Orthorhombic	3·3—3·44	6·5—7·0	1·660	$2(MgFe)O . SiO_2$
Dioptase	Rhombohedral	3·27—3·35	5·0	1·667	$H_2O . CuO . SiO_2$
Idocrase	Tetragonal	3·35—3·45	6·5		$? H(OH)_2Ca_{12} . (AlFe)_6(SiO_4)_{10}$
Zircon	Tetragonal	4·0—4·7	7·5	1·961	$ZrO . SiO_3$
Topaz	Orthorhombic	3·4—3·6	8·0	1·627	$[Al(O,F_2)]AlSiO_4$
Andalusite	Orthorhombic	3·1—3·2	7·5	1·624	$Al_2O_3 . SiO_2$
Cyanite	Triclinic	3·58—3·68	5—6		$Al_2O_3 . SiO_2$
Zoisite	Orthorhombic	3·28—3·35	6—7		$4CaO . 3Al_2O_3 . 6SiO_2 . H_2O$
Prehnite	Orthorhombic	2·92—3·01	6·0—7·0		$H_2Ca_2Al_2Si_3O_{12}$
Tourmaline	Rhombohedral	3·0—3·3	7·0—7·5	1·637	$7H_2O . 2Na_2O_3 . 9FeO . 6B_2O_3 . 14Al_2O_3 . 24SiO_2$ (very variable)
Serpentine	(? Amorphous)	2·47—2·60	3·0		$3MgO . 2SiO_2 . 2H_2O$
Sphene	Monosymmetric	3·3—3·7	5·0—5·5	1·631	$CaO . TiO_2 . SiO_2$
Turquoise	(Amorphous)	2·62—3·0	6·0		$2Al_2O_3 . P_2O_5 . 5H_2O$
Gypsum	Monosymmetric	2·28—2·33	1·5—2·0	1·53	$CaSO_4 + 2H_2O$
Amber	(Amorphous)	1·08	2·0—2·5	1·5	(Hydrocarbon compound)
Jet	(Amorphous)	1·02	2·0—2·3		(Hydrocarbon compound)

The cutting of gems is an industry in itself. Theoretically the angles of the facets should be calculated for each mineral from its refractive index, so as to give the greatest possible brilliance. Practically the form is determined largely by what portion of the gem is free from flaws. There are three principal ways of cutting precious stones; they may be: (1) Rose Cut, (2) Brilliant Cut, (3) cut En Cabochon. (1) A rose cut stone is roughly in the form of a low pyramid, formed of a number of triangular facets. The stone is set with its flat base towards the mount. (2) A brilliant cut stone has the general form of two pyramids, base to base, the one towards the setting being slightly truncated by a plane called the collet. The pyramid which is towards the light is markedly truncated by a plane called the table. (3) A stone cut *en cabochon* has a flat base towards the mount and a convex surface towards the light. Sometimes the surface towards the mount is concave, so that the stone forms a meniscus. A diamond which is to be cut is mounted in pewter, and then pressed on a wheel revolving 2,000 or 3,000 times per minute, with a pressure of 2 to 30 lb. produced by weights. The wheel is of iron, about 9 or 10 in. in diameter, and is dressed with a mixture of diamond dust and oil. The polishing of diamonds was unknown till the middle of the fifteenth century. At Birkenfeld, gems are polished on grindstones of about 4 ft. in diameter, driven by water wheels, and having their under parts dipping into the stream to keep the stones constantly wet. The operator lies at full length on a block hollowed out to fit the chest, and holds the gem on about the level of his eyes.

Position and dust combined usually pave the way for an early death of the workers, from consumption. Many imaginary virtues were attached to the different gems; in fact, the fear of the opal's ill-luck is not unknown now. Reference must be made to some of the works on gems for further details.—W.G.

Precipitate (*Chem.*) A solid formed by the addition to a solution of a gas, a liquid, a solid, or a solution. Thus, if the gas hydrogen chloride is passed into a strong solution of sodium chloride, the latter is precipitated from its solution; if the liquid alcohol be added to a solution of potassium chlorate in water, or ferrous sulphate in water, these salts are precipitated; if the solid zinc be added to a solution of copper sulphate, metallic copper is precipitated; if a solution of potassium iodide be added to a solution of lead acetate, both in water, lead iodide is precipitated. It will be seen, therefore, that to cause a precipitate two courses may be followed: (1) a change in the solvent may be effected so that the dissolved substance becomes less soluble; (2) a change in the dissolved substance may be effected so that a new substance is formed which is insoluble in the solvent used. The former course is a common expedient for purifying substances; the latter course is one commonly adopted in quantitative and qualitative analysis. The completeness of a precipitation depends on the insolubility of a precipitate in the solvent, so that for quantitative analysis the precipitate should be as insoluble as possible; while in qualitative analysis the precipitate need not be so insoluble, although the delicacy of a test depends on the insolubility of a precipitate in many cases For example, when excess of a solution of tartaric acid is added to a solution of potassium nitrate, a white precipitate of cream of tartar is formed, and this is a respectable test for potassium when properly performed; but potassium is never estimated in this way because the precipitate is too soluble in water. *See* QUALITATIVE *and* QUANTITATIVE ANALYSIS.

Precipitated Chalk. *See* CALCIUM COMPOUNDS.

Precipitation (*Meteorol.*) Precipitation occurs when moist air is cooled below the dewpoint, the moisture taking the form of rain, snow, hail, dew or frost depending on the conditions under which condensation takes places and is maintained.

Precipitato, Precipitoso (*Music*). Hurriedly.

Preciso, Precisione, con (*Music*). With precision.

Prehistoric Architecture. Megalithic structures are the most important examples of prehistoric architecture which have lasted till the present time. They consist of circles and avenues of large stones, either in the form of MENHIRS (single upright stones) or DOLMENS (pairs of vertical stones supporting lintels). The circles are known as CROMLECHS.

Prehnite (*Min.*) An acid calcium aluminium orthosilicate, $H_2Ca_2Al_2Si_3O_{12}$. Pseudo-Rhombic. Usually in green or yellowish mammillated masses, with a radiating crystalline structure, rarely showing distinct terminations to the crystals. It is found in some eruptive and metamorphic rocks. Boyleston, Old Kilpatrick, etc., near Glasgow; Edinburgh; Dauphiné; China, etc.

Preliminary (*Typog.*) This term is used to denote matter that precedes the main text of a work, *e.g.* title, preface, contents, list of illustrations, etc.

Preller's Leather. *See* CROWN LEATHER.

Preparing, Prepared (*Lace Manufac.*) Relates to yarn that is rolled or calendered.

Pre-Raphaelite Brotherhood (*P.R.B.*) An association of artists formed about 1848, and consisting at first of W. Holman Hunt, D. G. Rossetti, and J. E. Millais. Subsequently there were associated with them T. Woolner, F. G. Stephens, and J. Collinson. The objects of the association were a closer study of nature, and to protest against certain academic dogmas. *The Germ*, the organ of the association, of which only four numbers were published, was issued in 1850. Its principle was "to enforce and encourage an entire adherence to the simplicity of nature." This principle was to apply to poetry as well as painting. Ruskin described the methods of the association as an attempt "to paint things as they probably did look and happen, not as, by rules of art developed under Raphael, they might be supposed to gracefully, deliciously, or sublimely have happened." The association continued until 1854.

Press. The literature of newspapers; collectively the representatives of newspapers who attend meetings for the purpose of taking reports.

—— (*Bind.*) The name given to several appliances used in bookbinding, *e.g.* arming, blocking, lying, sewing, standing press, etc. (*q.v.*)

—— (*Eng., etc.*) A general name for a machine, worked either by hand or power, adapted for many purposes, *e.g.* crushing various substances; forcing a body to assume a more compact form; expressing oil, wine, etc.; impressing a design on metal or other substance; printing. *See* TYPOGRAPHY.

Pressed Bricks (*Build.*) Bricks that have been pressed in a mould before baking. This renders them very dense.

Pressed Glass. *See* GLASS MANUFACTURE.

Presse Pate (*Paper Manufac.*) An apparatus for converting wet pulp into sheets in papermaking.

Presser, Flatware (*Pot.*) A potter who makes such flat ware as plates, saucers, dishes, etc.

Pressing (*Lace Manufac.*) A process that it is necessary brass bobbins should undergo after being filled with material, to restore them to a workable thickness.

Pressing Block (*Bind.*) One of the wooden blocks used to fill up a STANDING PRESS (*q.v.*) when there are not sufficient books for the purpose.

Pressing Boards (*Print.*) Glazed boards used for pressing printed sheets in order to give them a slight glaze and remove the indentations caused by the type.

Pressman (*Print.*) A term used in England to distinguish the operator of a hand press from the minder of a printing machine.

Press Pin (*Bind.*) A bar of iron used as a lever for operating standing and lying presses.

Press Proof (*Print.*) The final proof marked by the author or publisher "for press."

Press Revise (*Typog.*) The first sheet printed at press or machine. The reader compares it with the author's press proof as a final check against errors and imperfections.

Press Rolls (*Paper Manufac.*) Heavy iron rolls used for pressing the wet paper after leaving the couch rolls.

Pressure. A force exerted on an object (or quantity of material) and acting towards the object. The term pressure is often confined to forces which produce a STRESS (*q.v.*), but do not produce motion. Pressure is usually measured in units of force per unit area.

—— (*Elect. Eng.*) A term often used to denote POTENTIAL DIFFERENCE *or* ELECTROMOTIVE FORCE.

Pressure, Barometric (*Meteorol.*) Atmospheric air exerts a pressure in all directions, and its amount varies according to its density. The air at sea level, weighed down by the air above it, exerts a pressure of nearly 15 lb. per square inch of surface, against which it presses, and this pressure is measured by the barometer.

Pressure Areas (*Meteorol.*) Areas over which relatively "high pressure" or "low pressure" prevails for either short or long intervals of time.

Pressure Forging (*Eng.*) The shaping of wrought iron objects by means of dies actuated by a HYDRAULIC PRESS (*q.v.*)

Pressure Gauge (*Eng.*) An instrument for measuring the pressure of a gas or liquid. The pressure of the fluid actuates the mechanism of the gauge in a great variety of ways; in one of the commonest types of steam gauge the pressure tends to straighten out a bent tube, and the movement produced is communicated to a pointer turning on an axis in the centre of a dial.

Pressure Gradients (*Meteorol.*) *See* GRADIENT.

Pressure of the Atmosphere. This is approximately 15 lb. per square inch. The Normal Pressure used in physics and chemistry as a standard of reference is equal to that exerted by a column of mercury 76 cm. high, and is equal to about 1,013,300 dynes per square centimetre. It has been proposed to take a pressure of 1,000,000 dynes per square cm. (10^6 dynes) as a standard.

Press View. It is customary before an exhibition, etc., is opened to the public to fix a day on which representatives of the Press are admitted to view the exhibits for the purpose of criticism.

Presswork (*Print.*) A term expressing the operations of printing at hand press. It includes laying on the forme, dressing the tympan, making and cutting out the frisket, making ready, inking the forme, laying the sheet on the tympan, running the forme beneath the platen, taking the impression, running out the forme, lifting the tympan, removing the printed sheet, etc.

Prestissimo (*Music*). Very quick.

Presto (*Music*). Quick.

Preticelli Ware. *See* GLASS MANUFACTURE.

Pricker (*Foundry*). A wire used for forming vents in the upper part of a mould to allow the escape of the gases produced when the molten metal is poured in.

—— (*Mining*). A rod used for forming the "touch hole" in blasting with powder.

Pricking Up (*Build.*) The first coat of plaster on a lathed partition or ceiling.

Prima (*Music*). First, chief, as *prima volta, primo* (abbreviated 1°), first time, used before a repeat, when on the repetition other music is to be substituted for that portion marked 1°; *prima donna*, chief operatic female singer.

—— (*Print.*) The piece of copy containing the first words of the next "take" or sheet.

Primary (*Geol.*) A term employed by the older geologists as synonymous with what would now be subdivided as the Deuterozoic (Carboniferous and Devonian), Protozoic (Silurian, Ordovician, and Cambrian), and Eozoic (or Pre-Cambrian) systems.

Primary Alcohol (*Chem.*) *See* ALCOHOL. For examples of primary alcohols *see also* METHYL ALCOHOL *and* PROPYL ALCOHOL.

Primary Amine (*Chem.*) *See* AMINES. For the reactions of a typical primary amine *see under* ETHYLAMINES *and* METHYLAMINE.

Primary Bow (*Meteorol.*) *See* RAINBOWS.

Primary Cells (*Elect.*) *See* CELLS, PRIMARY.

Primary Coil (*Elect.*) That coil of an induction coil, transformer, etc., through which flows the primary current, *i.e.* the original current, whose fluctuations are to be utilised in order to induce another or secondary current in the secondary coil of the apparatus.

Primary Colours (*Light*). *See* COLOURS, PRIMARY.

Primary Hydrocarbon (*Chem.*) One which contains no carbon atom linked to more than two others. *See under* PARAFFINS.

Prime. A number which contains no factors except itself and unity, *e.g.* 3, 5.

—— (*Music*). The generator. *See* HARMONICS.

——, **Priming** (*Paint.*) Covering a canvas or other painting surface with a layer of colour to form a ground. The first coat of paint on woodwork, generally composed of red lead, turpentine, and a little linseed oil. *See* HOUSEPAINTING.

Prime Conductor (*Elect.*) The positive conductor of a frictional or an electrostatic machine.

Prime Vertical (*Astron.*) The vertical circle at right angles to the meridian, *i.e.* which passes through the east and west points of the horizon.

Priming (*Dec.*) The first coat of paint given to a wood, cement, or other surface to form a foundation for the subsequent coats. It is important that it be mixed thin; that is, with sufficient oil to penetrate well into the wood, etc., but not wholly so. The most common priming used is a mixture of white lead and red lead in the proportion of about 1 oz. of the latter to 1 lb. of the former. Yellow ochre mixed with white lead is often employed, but it is important that the ochre be very finely ground, in order that it may penetrate the pores of the wood and form a key for the subsequent coats of paint. An imperfect priming is often the cause of subsequent blistering of the paint. Puttying is executed after the priming coat, to fill up all the cracks and bring all inequalities to a level surface. If the putty is applied to the raw wood or cement, it would extract the oil from the putty and cause it to drop out when dry. It is important when giving the priming coat to see that the brush reaches every part of the surface, into all the cracks, etc. It is also important that the work should be free from moisture when the priming coat is applied. *See* PRIME.

—— (*Eng.*) The technical name for frothing or foaming in a steam boiler. In violent ebullition the bubbles of steam rise so rapidly that particles of water are sprayed up into the steam space and suspended mechanically. The risk of this priming being carried off in the steam pipe is serious, as it disarranges the engine valves and is liable to knock out the cylinder heads. Hence the importance of dry steam, which commercially is held to be such when containing less than $2\frac{1}{2}$ per cent. of moisture. The principal causes of priming, among others, are greasy and dirty water; the injudicious use of caustic and other "softeners" *in* the boiler; insufficient

steam space; too large a steam pipe; deficient water surface area; forced firing; and faulty design. The last named is a more common cause than contracted steam space. As remedial measures the following may be noted: (1) Clean water and passing the condenser feed through an oil separator. (2) Keeping as great a water surface as possible, a vital feature being to ensure the water surface covering at least half the area of each space left for down currents. (3) The use of an anti-priming or dry pipe (*q.v.*) for collecting steam. (4) The area of the steam pipe to be in proportion to the capacity of the boiler. (5) Regulating the water surface so that the steam shall not rise at the rate of more that 2·5 ft. per second; that is to say, the minimum water disengaging surface, in square feet, may be ascertained by dividing the number of cubic feet of steam generated per second by 2·5. (6) Attention to the design of boilers in relation to the foregoing. To remedy existing faulty design, baffle plates may be fixed inside the boiler or the steam pipe area reduced. Though the lowering of the initial pressure may reduce the efficiency of the engine, it is often a lesser evil than that of priming or installing a new boiler.—C. H. N.

Priming of the Tides (*Astron.*) At the time of spring tides the interval between the corresponding tides of successive days is less than the average, and then the tides are said to be "prime."

Priming Valve (*Eng.*) A valve fitted to cylinders in steam engines to afford a vent for water carried in by PRIMING (*q.v.*)

Primo (*Music*). The treble part of a duet, the other part being the *secondo*. *See also* PRIMA.

Primrose Chrome (*Dec.*) The lightest grade of chrome yellow, sometimes called lemon chrome, although this is strictly a slightly deeper colour.

Primuline. *See* DYES AND DYEING.

Principal (*Build.*) A PRINCIPAL RAFTER (*q.v.*)

—— (*Music*). (1) An open metal stop on organs (*see* ORGAN, p. 441). This stop is of 4 ft. pitch on the manuals and of 8 ft. on the pedals, and it is in the Great Organ Principal that the tuner lays the original bearings from middle C to the octave above. (2) Subject, the chief theme of a movement.

Principal Focus (*Light*). Parallel rays of light, after falling upon a mirror or lens, converge to, or appear to diverge from, a point on the axis; this point is termed the PRINCIPAL FOCUS.

Principal Plane of a Crystal (*Phys.*) A plane drawn so as to contain the Optic Axis of a crystal. If the plane be drawn at right angles to a face of the crystal, it is termed the Principal Plane of that face.

Principal Planes of a Lens (*Light*). A pair of planes drawn through the PRINCIPAL POINTS (*q.v.*) at right angles to the axis of the lens.

Principal Points of a Lens (*Light*). These are two points so situated with regard to a lens that a ray travelling towards one of them will emerge, after passing through the lens, as if it came from the other, but parallel to its original direction. These points are also termed OPTICAL CENTRES and EQUIVALENT POINTS.

Principal Rafters (*Build.*) The rafters of a truss, the timbers on which the purlins rest. *See also* ROOFS.

Print. A general term for an impression taken from engraved plates, types, etc. *See also* PHOTOGRAPHY.

—— (*Pattern Making, etc.*) A projection on a pattern. This forms a recess in the mould into which the end of a CORE (*q.v.*) is fitted to hold it in place.

Printer's Devil. A term applied to the junior apprentice in a printing works.

Printer's Ream. Twenty-one and a half quires of 25 sheets, or 516 sheets in all, to allow, after making ready and spoilage, of a product of at least 508 good copies.

Printing Frame (*Photo.*) A wooden frame which holds a negative closely in contact with the printing paper during the process of PRINTING (*q.v.*) When paper or film negatives are used the printing frame is fitted with a glass front.

Printing Ink. *See* INKS.

Printing Telegraph (*Elect. Eng.*) An instrument which prints the message on a strip of paper either in the Morse alphabet (*q.v.*) or, in certain cases, in ordinary type.

Priory. A religious house, *e.g.* a monastery or convent, presided over by a prior or prioress; they rank respectively next to an abbot and abbess.

Prising (*Eng., etc.*) Moving an object by means of a lever or crowbar. Forcing open by leverage, *e.g.* a door or box.

Prism. A solid whose sides are parallelograms, and whose ends are equal polygons, lying in parallel planes. Prisms are described by the form of the base (or cross section), *e.g.* as triangular, square based, etc.

—— (*Phys.*) The term is applied, especially in physics, to a portion of refracting material in the form of a prism, usually of triangular cross section. BOTTLE PRISMS are glass vessels of triangular cross section with accurately plane sides, for containing a refracting liquid. *See also* ERECTING PRISM, SPECTROSCOPE, *etc.*

Prismatic Camera (*Astron.*) A camera used for spectroscopic purposes when the prism or grating is placed in front of the object glass.

Prismatic Compass. A form of compass used in surveying. It is provided with a sight and reflecting prism so arranged that while an object is viewed through the sight, the bearing of the line to it may be simultaneously read by means of the reflection of the graduated scale in the prism.

Private View. The privilege of viewing pictures, etc., granted to exhibitors, their friends, and others, prior to the admission of the public.

Process. *See under* PHOTO ENGRAVING.

—— (*Biol.*) A portion of some cell, organ, or other structure which forms a projection; *e.g.* many bones have processes, which serve as points of attachment for muscles, ligaments, etc.

—— (*Mining*). A Cornish term for the percentage of metal in a given ore.

Prochous (*Archæol.*) A small pitcher-shaped vase somewhat resembling the Œnochœ. Used by the Greeks for pouring water over the hands before meals.

Producer (*Eng.*) A form of cupola furnace used for making PRODUCER GAS (*q.v.*)

Producer Gas (*Eng.*) A mixture consisting essentially of hydrogen, oxides of carbon (CO and CO_2),

nitrogen, etc., formed by blowing air through red-hot coke, coarse coal, or other carbonaceous fuel. There are many modifications of the process. The general result is a gaseous fuel of little or no illuminating power but considerable calorific value, suitable for use in furnaces of nearly all kinds, and also for driving gas engines.

Products of Combustion. The results of the combustion of ordinary fuel are carbon dioxide, CO_2; water vapour, H_2O; carbon monoxide, CO, etc. If the gases from a furnace are rich in CO, they can be utilised further as fuel.

Profile. The outline or contour of anything, especially the human face as seen sideways; also the outline of a building, projection of a moulding, piece of country, etc., shown by section.

—— (*Pot.*) A mould made of fired pottery and used by the plate or saucer maker to form the foot of the piece.

Progression. A series or succession of quantities each one bearing a definite relation to those which precede and follow it, *e.g.* a common difference in ARITHMETICAL PROGRESSION, or a common ratio in GEOMETRICAL PROGRESSION. Thus 1, 5, 9, 13 are numbers in arithmetical progression, and 1, 5, 25, 125 are in geometrical progression.

Projection. A method of depicting an object on a plane surface by the use of straight lines called projectors. It can be orthographic projection or perspective projection. In the latter case the visual rays are the projectors. If a straight line be drawn from a point at right angles to a plane, its intersection with the plane is the ORTHOGRAPHIC PROJECTION of the point; also, if a straight line be drawn from a point to the eye of the spectator, it cuts the plane of the picture at a point which is the PERSPECTIVE PROJECTION of the original point.

Projection Lens. A lens or combination of lenses used for the formation of an image upon a screen. *See* LANTERN OBJECTIVE.

Prominences (*Astron.*) Incandescent clouds, varying in size and form, round the limb of the sun. They are projections from the chromosphere, and attain enormous dimensions. They can be seen or photographed any time when the sun shines.

Pronaos (*Architect.*) *See* CELL.

Prong Chuck. A forked chuck used to give rotation to a piece of wood mounted between the centres of a lathe.

Prony Brake (*Eng.*) *See* DYNAMOMETERS, MECHANICAL.

Proof (*Engrav., etc.*) An impression taken from an engraved plate, lithographic stone, etc., to prove the condition and progress of the engraving, etc., during its execution; one of a limited number of impressions taken before the title, etc., is added to the plate or stone, and known as a PROOF IMPRESSION, FIRST PROOF, or PROOF BEFORE LETTERS. *See* FIRST PROOF.

—— (*Typog.*) Preliminary impression of type matter either in slip, page, or sheet form.

——, **Artist's** (*Engrav., etc.*) A proof of an engraving, etc., signed by the artist. The signature of the artist is a guarantee of the satisfactory condition of the plate.

——, **Lettered** (*Engrav., etc.*) A proof of an engraving, etc., that bears in the margin the title, etc. *See under* PROOF

Proof, Remarque (*Engrav., etc.*) A proof of an engraving, etc., signed by the artist, and bearing in addition a small design, sketch, or other distinguishing mark placed on the margin of the engraving.

Proof Bar (*Met.*) A bar of steel which can be withdrawn from a cementation furnace to show the progress of the operation of CEMENTATION (*q.v.*)

Proof Corrections (*Typog.*) The method of marking errors or emendations in proofs is practically uniform in all printing offices, and the same method is usually adopted by writers. On the next page will be found an example of a corrected proof containing a number of the more common mistakes, and the marks by which the printer is able to rectify them.

Proof Load (*Eng.*) A load greater than that which a structure has to bear when in use, applied to test the strength, deflection, or deformation, etc., of the structure.

Proof Plane (*Elect.*) A small metal disc fixed to an insulated handle, used for transferring small charges of electricity from charged conductors.

Proof Reader (*Typog.*) *See* READER.

Proof Spirit (*Chem.*) A mixture of alcohol (ethyl alcohol) and water defined by Act 58, George III., as "being such as shall at a temperature of 51° F. weigh exactly $\frac{12}{13}$th part of an equal measure of distilled water" (51° F. = 10·5° C.) It contains 49·24 per cent. by weight of alcohol, or 57·09 per cent. by volume of alcohol. The duty on all alcoholic liquors is charged according to the amount of proof spirit they contain, 11*s.* per gallon of proof spirit. Liquors containing more alcohol than proof spirit are called overproof, and those containing less are called underproof. If an alcoholic liquor is described as 10° overproof, it means that 100 parts by volume would give by dilution with water 110 parts by volume of proof spirit. If the liquor is described as 10° underproof, it means that 100 parts by volume of the liquor contain (100-10) = 90 parts by volume of proof spirit.

Proof Stress (*Eng.*) The greatest stress to which a substance can be subjected without exceeding the ELASTIC LIMIT (*q.v.*)

Propane (*Chem.*) $CH_3.CH_2.CH_3$. A paraffin hydrocarbon. *See* PARAFFINS.

Propeller (*Eng.*) *See* SCREW PROPELLER.

Proper (*Her.*) The tincture of a charge is very frequently its own natural colouring; it is then blazoned "proper."

Proper Motion (*Astron.*) After allowing for all the common motions of stars, it is found that they really change their position with reference to each other, each having a particular or proper motion of its own.

Propionic Acid (*Chem.*) $CH_3.CH_2.COOH$. A colourless liquid. Smells like acetic and butyric acids; boils at 140°; soluble in water; insoluble in a solution of calcium chloride. Boiled with bromine it yields α-brompropionic acid, $CH_3.CHBr.COOH$. It occurs in small amount in many different fermentations of sugars, such as glucose and milk sugar. It is best prepared by the hydrolysis of its nitrile—propionitrile or ethyl cyanide—by boiling with a dilute acid or with a solution of caustic potash. The nitrile is obtained by heating ethyl iodide and potassium cyanide at 180° in a sealed tube, and distilling the addition product so formed.

"THE CENSOR OF THE AGE." 9

Thomas Carlyle, a great thinker. essayist, and historian, was born at Ecclefechan, in Dumfriesshire, in the year 1795. He was educated at the burgh school of Annan, and afterwards at the University of Edinburgh. Classics and the hisher mathematics were his favourite studies; and he was more espe cially fond of astronomy. He was a teacher for some years after leaving the university. For a few years after this he was enaged in minor literary work; and translating from the German occupied a large portion of his time. In 1826 he married Jane Welsh, a woman of abilities inferior only to his own. His first original work was *Sartor Resartus* ("The Tailor Repatched"), which appeared in 1834, and excited a great deal of attention. Perhaps his most remarkable book is The French Revolution. In 1865 he completed the hardest piece of work he had ever undertaken, his *History of Frederick II.*

One of the crowning external honours of CARLYLE'S life was his appointment as *Lord Rector* of the University of Edinburgh in 1866; but at the very time that he was delivering his famous and remarkable Installation Address, his wife lay dying in London.

This stroke brought terrible sorrow on the old man; he never ceased to mourn for his loss, and to recall the virtues and the beauties of character in his dead wife. "The light of his life," he said, "was quite gone out"; and he wrote very little after her death.

Carlyle was an author by profession, a teacher of and prophet to his countrymen by hismission, and a student of history by the deep interest he took in the life of man. He was always more or less severe in his judgments—he has been called The Censor of the Age"—because of the high ideal which he set up for his own conduct and the conduct of others. He shows in his historic writings a splendour of imagery and a power of dramatic grouping second only to Shakespeare. In command of words he is second to no other modern English writer.

B

"THE CENSOR OF THE AGE." 9

THOMAS CARLYLE, a great thinker, essayist, and historian, was born at Ecclefechan, in Dumfriesshire, in the year 1795. He was educated at the burgh school of Annan, and afterwards at the University of Edinburgh. Classics and the higher mathematics were his favourite studies; and he was more especially fond of astronomy. He was a teacher for some years after leaving the University. For a few years after this he was engaged in minor literary work; and translating from the German occupied a large portion of his time. In 1826 he married Jane Welsh, a woman of abilities only inferior to his own. His first original work was *Sartor Resartus* ("The Tailor Repatched"), which appeared in 1834, and excited a great deal of attention. Perhaps his most remarkable book is *The French Revolution.* In 1865 he completed the hardest piece of work he had ever undertaken, his *History of Frederick II.*

One of the crowning external honours of Carlyle's life was his appointment as Lord Rector of the University of Edinburgh in 1866; but at the very time that he was delivering his famous and remarkable Installation Address, his wife lay dying in London. This stroke brought terrible sorrow on the old man he never ceased to mourn for his loss, and to recall the virtues and the beauties of character in his dead wife. "The light of his life," he said, "was quite gone out"; and he wrote very little after her death.

Carlyle was an author by profession, a teacher of and prophet to his countrymen by his mission, and a student of history by the deep interest he took in the life of man. He was always more or less severe in his judgments—he has been called "The Censor of the Age"—because of the high ideal which he set up for his own conduct and the conduct of others. He shows in his historic writings a splendour of imagery and a power of dramatic grouping second only to Shakespeare's. In command of words he is second to no modern English writer

B

EXPLANATION OF THE CORRECTIONS.

1. The line should not be "indented" (*see* 12) in this case, the reason being that the first words of the paragraph are altered to capitals and small capitals.
2. When it is required to alter words from lower-case letters to capitals, three lines are placed beneath them; to small capitals, two lines: and to italics, one line.
3. Substitute a comma for a full-point.
4. The letter "g" is upside down.
5. The letter "h" is to be taken out, or "deleted."
6. A "hyphen" is omitted. In all cases of omission a caret (∧) is marked in the place, and the character written in the margin, except in the case of long sentences being left out, when the words "Out—see copy" are written instead.
7. Substitute capital U for lower-case letter. *See* 2.
8. The letter "g" is to be inserted. *See* 6.
9. *w.f.* (wrong fount) indicates that the letter marked belongs to another fount of type.
10. *trs.* signifies the transposition of letters or words.
11. Underlined for italics. *See* 2.
12. *N.P.*, or *new par.*, commence a new paragraph by indenting the line one em.
13. As in the case of roman being marked to italic, the words required to be in roman are underlined once, and *rom.* (roman) is written in the margin.
14. *See* 13.
15. The matter has some foreign substance between the lines, causing them to appear crooked. Lines are written above and below the words not in alignment.
16. The paragraph should not have been broken here, but should "run on," these words being placed in the margin.
17. The letter is face downwards.
18. Substitute a full-point for the semicolon, and commence a new sentence.
19. A space to be put in between the two words, to separate them.
20. The letters in the word are too far apart, and should be closed up.
21. A space is standing up.
22. A battered letter.
23. When inverted commas or superior letters are to be inserted, they are usually written above the sign shown in the margin.
24. The reader has mistakenly crossed out the word. To indicate that it must be retained, dots are placed beneath it, and the Latin word *stet* (let it stand) is written in the margin.
25. The spaces between the words are not equal
26. Apostrophe to be inserted. *See* 23.
27. Delete the word "other"

Proportion. Proportion is the equality of ratios. Thus four quantities, *a*, *b*, *c*, *d*, are in proportion if

$$\frac{a}{b} = \frac{c}{d}$$

Proportional Arms (*Elect.*) *See* WHEATSTONE'S BRIDGE.

Proportional Compasses. A pair of compasses consisting of two bars each pointed at both ends, and provided with a common fulcrum which can be placed at any required position along the bars. With the fulcrum fixed in any position there is a definite ratio between the extent to which the ends open out, and this ratio is kept constant while the instrument is being used for copying any drawing on a different scale from the original.

Propulsion System of Ventilation. By this method of ventilation fresh air is driven mechanically, by means of bellows, pumps, or fans, into the building.

Propyl (*Chem.*) A name given to the residue remaining when one hydrogen atom is removed from propane. As this can be done in two ways, there is: (1) The normal propyl group obtained by removing one atom of hydrogen from either of the terminal carbon atoms of propane. (2) The isopropyl group obtained by removing one atom of hydrogen from the middle carbon atom of propane.

$CH_3 . CH_2 . CH_2$, normal propyl.
$CH_3 . CH . CH_3$, isopropyl.
$\quad\quad\;\;|$

Exs.: Conine (*q.v.*) is *a*-propylpiperidine. Cymene (*q.v.*) is paramethylisopropylbenzene.

Propylæa (*Architect.*) A monumental gateway in front of a building or group of buildings. The propylæa of the Acropolis at Athens is a fine example.

Propyl Alcohols (*Chem.*) (1) Normal propyl alcohol, $CH_3CH_2CH_2OH$, is a colourless liquid. Smells like ordinary alcohol; boils at 97°; soluble in water; insoluble in strong calcium chloride solution. Chemically its behaviour is like that of ethyl alcohol. It is one of the constituents of fusil oil, and can be prepared from some kinds of fusil oil by fractional distillation. It also occurs in small quantities in various fermentations of cane and grape sugar. Artificially it can be made by the reduction of the anhydride of propionic acid by sodium amalgam. (2) Isopropyl alcohol, $CH_3 . CHOH . CH_3$, is a colourless liquid. Alcoholic smell; boils at 83°; soluble in water, and forms various hydrates with it. The hydrate $2C_3H_8O . H_2O$ has a constant boiling point at 80°. On oxidation it yields acetone. It may be obtained by reduction of acetone with sodium amalgam. *See* KETONES. It is also prepared by boiling isopropyl iodide with water and a weak alkali, such as lead hydroxide. The isopropyl iodide may be obtained from glycerine by distilling it with amorphous phosphorus and an excess of fuming hydriodic acid. Normal propyl alcohol can be converted into isopropyl alcohol by heating it with concentrated sulphuric acid to form propylene, uniting the latter to concentrated sulphuric acid and distilling the product with water:

$$\begin{array}{cccc} CH_3 & CH_3 & CH_3 & CH_3 \\ | & | & | & | \\ CH_2 \;\; - & CH & CH . HSO & CHOH \\ | & \| & | & | \\ CH_2OH & CH_2 & CH_3 & CH_3 \end{array}$$

Proscenium. The part of a modern theatre stage that lies between the curtain or drop scene and the orchestra; the curtain and the frame from which it hangs. In an ancient theatre the proscenium comprised the whole of what is now known as the stage, but it was merely a narrow raised platform, with a scene at the back. The actors stood at the front.

Prostylar *or* **Prostyle** (*Architect.*) A temple having a columnar porch at one end only. *See* ANTA *and* AMPHIPROSTYLE.

Protamines (*Chem.*) The simplest proteids. They are found united with nuclein in the heads of the spermatozoa of a number of fish, *e.g.* salmon, sturgeon, herring, mackerel, and others, and they are named after the fish from which they are obtained. The protamines from the fishes mentioned are called respectively salmine, sturine, clupeine, scombrine (Latin names). The free protamines are difficult to prepare in pure condition, and are usually obtained as sulphates. The formulæ of the four protamines mentioned are approximately:

Sturine	$C_{24}H_{71}N_{17}O_9$
Scombrine	$C_{32}H_{72}N_{16}O_8$
Clupeine	$C_{30}H_{62}N_{14}O_9$
Salmine	$C_{30}H_{57}N_{17}O_6$.

They are white solids; not coagulated by heat; their solutions are precipitated by ammonium sulphate and by common salt; they are fairly strong bases; their sulphates are soluble in water, insoluble in alcohol, and are precipitated by picric acid. They give the biuret reaction, and are precipitated by the alkaloid reagents (*q.v.*) They are hydrolysed by trypsin, but not by pepsin. Dilute acids also hydrolyse them. The first products of hydrolysis are called PROTONES, and are the peptones of the protamines. Further hydrolysis resolves them into the Hexone bases, arginine, histidine, lysine, of which arginine is much the more frequent and abundant (84 per cent. in the case of salmine):

Arginine = guanidine-*a*-amino-valerianic acid,

$$\begin{array}{l} \quad\quad NH_2 \\ \quad\quad\;\, | \\ HN = C . NH . CH_2 . CH_2 . CH_2 . CHNH_2 . COOH \end{array}$$

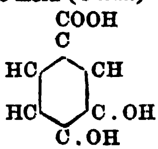
Histidine = $C_6H_9N_3O_2$, of unknown constitution.
Lysine = *a*, *ε*-diaminocaproic acid = $CHNH_2CH_2 . CH_2 . CH_2 . CHNH_2 . COOH$.

Proteids (*Chem.*) A general term used to include a large number of substances which form the most important constituents of the bodies of plants and animals. These substances are composed of carbon, hydrogen, nitrogen, oxygen, sulphur, and phosphorus, the first four being always present, the last two not always. The constitution is unknown in every case, and only in the case of the simplest members is even the formula approximately known. They are called by one general name because of the mode of their occurrence, their optical activity (all lævo-rotatory), the general similarity of their decomposition products, their colloidal character (although many of them can be crystallised, they are nevertheless colloids), their colour reactions. The proteids may be divided into the following classes: (1) Simple proteids, such as the albumins (*q.v.*), globulins (*q.v.*), casein (*q.v.*) (2) Compound proteids, such as hæmoglobin (*q.v.*); the nucleo-proteids, which are compounds of simple proteids with a substance (or substances) called nuclein, which forms the chief constituent of cell nuclei and yields nucleic acids (*q.v.*) on decomposition. (3) Albuminoids, such as gelatine (*q.v.*) and elastin. (4) Protamines (*q.v.*) Among the products of hydrolysis of proteids,

whether the hydrolysis is effected by acids, alkalis, or enzymes, may be mentioned glycocoll (*q.v.*), alanine (*q.v.*), leucine (*q.v.*), aspartic acid (*q.v.*), glutaminic acid (*q.v.*), tyrosine (*q.v.*), arginine, histidine, lysine (*see under* PROTAMINES for these three), and other products. *See* HÆMOGLOBIN.

Proterozoic System (*Geol.*)

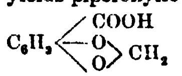
Protocatechuic Acid (*Chem.*)



Pale yellow needles, containing one molecule water of crystallisation; the anhydrous acid melts at 199°, and loses carbon dioxide, forming pyrocatechol (*q.v.*) Soluble in water, alcohol, ether. Ferric chloride gives a green colour to its solution, turning blue, then red on addition of alkali; reduces ammoniacal silver. On treating it with halogen alkyls and alkylens and caustic potash, it yields ethers; *e.g.* methyl iodide yields vanillic and veratric acids,

$$\underset{3}{C_6H_3}(\underset{4}{OCH_3}).\underset{1}{OH}.COOH \text{ and } C_6H_3(OCH_3)_2COOH.$$

Methylene iodide yields piperonylic acid,



See PIPERONAL. It is formed on fusing certain resins with caustic potash, such as asafœtida, catechin, kino; and in the same way from piperic acid. *See* PIPERINE. It is also formed by heating pyrocatechol (*q.v.*) with ammonium carbonate at 140°.

Protoplasm (*Biol.*) The essential living substance of animal and plant organisms. It is of a viscous consistency and semitransparent. It is an unstable complex compound of carbon, hydrogen, oxygen, nitrogen, sulphur, and perhaps phosphorus.

Protozoic (*Geol.*) One of the four great divisions into which the whole of the Sedimentary Rocks have been divided. The oldest during which life first came into being upon the Earth is the Eozoic. Next to this, when the earliest forms of life yet known prevailed, is the one under notice; following that comes the Deuterozoic or second type; and finally appear the forms of life which are more or less closely related to those of the present day, which is called the Neozoic. It begins with the Dyas or Lower New Red. This classification is based upon the general facies of the Life of the Past at different periods in the Earth's history.

Protractor. A divided scale used for marking angles on paper. It may be straight, circular, semicircular, etc.

Protuberances (*Astron.*) *See* PROMINENCES.

Proustite (*Min.*) Silver sulpharsenite, $3Ag_2S.As_2S_3$. Silver = 65·4, sulphur = 19·4, arsenic = 15·2 per cent. Rhombohedral and hemimorphic, occurring in deep red crystals with a submetallic lustre. Chiefly from the Harz Mountain mines. It is also called RUBY SILVER. *See* PYRARGYRITE.

Prunus (*Botany*). An important genus of the *Rosaceæ*. The following are the chief species: *P. cerasus*, the cherry; *P. amygdalus*, the almond; *P. persica*, the peach; *P. domestica*, the plum; *P. armeniaca*, the apricot.

Prussian Blue (*Chem.*) When ferric chloride is added to an excess of a solution of potassium ferrocyanide, a blue precipitate is formed which is completely soluble in much water, giving a blue solution, but insoluble in salt solutions. This substance is called soluble Prussian blue; it is potassium ferric ferrocyanide, $K.Fe.\left\{Fe(CN)_6\right\}$. When potassium ferrocyanide is added to ferric chloride solution, a mixture of soluble and insoluble Prussian blue is formed, and if the precipitate is heated with ferric chloride all the former compound is converted into the latter, and ferric ferrocyanide or insoluble Prussian blue, $Fe_4\left\{Fe(CN)_6\right\}_3$, is obtained. It contains water, which cannot be expelled without decomposition. It is a blue solid with coppery lustre; soluble in ammonium tartrate, giving a violet solution, and in oxalic acid, giving a blue solution. It is decomposed by caustic potash: $Fe_4\left\{Fe(CN)_6\right\}_3 + 12KOH = 3K_4Fe(CN)_6 + 4Fe(OH)_3$. *See also* MERCURY COMPOUNDS. Commercial Prussian blue is a mixture of soluble and insoluble Prussian blue and Turnbull's blue (*q.v.*), obtained by adding ferrous sulphate to potassium ferrocyanide, and oxidising the precipitate with chlorine water or bleaching powder, then treating it with hydrochloric acid to remove ferric hydroxide. It is used as a paint.

—— (*Dec.*) Is one of the most important and one of the cheapest blues used by the house painter. It is made by adding ferrous sulphate to a solution of potassium ferrocyanide. The blue works well both in oil and water. In the lump it possesses, if of good quality, a certain unmistakable copper-like hue. It cannot be used with lime, is not quite permanent when exposed to light, but sufficiently so for all ordinary purposes. Chinese blue is high quality of the same pigment; Brunswick blue, a mixture of Prussian blue and barytes.

Prussian Brown (*Dec.*) A pigment very similar in colour to umber, and made by partially carbonising Prussian blue. It is now very little used.

Prussiate Bath. The solution of yellow prussiate of potash or potassium ferrocyanide used in the BLUE PROCESS for copying.

Prussic Acid (*Chem.*) *See* HYDROCYANIC ACID.

Psaltery (*Archæol.*) A mediæval musical instrument consisting of thirteen strings and a sounding board. The strings were played by plucking them.

Psammite (*Geol.*) A word long in use on the Continent to denote any kinds of rock which consist essentially of sand, whether coarse or fine, and now coming into use in Britain in the adjective form Psammitic to convey the same idea.

Pseudo Acids and Bases (*Chem.*) A pseudo acid is a substance which does not by itself show acid properties, but which on solution in a suitable solvent undergoes electrolytic dissociation at a measurable rate into acid ions. The original substance and its ions have not the same constitution, for during the resolution into ions isomerisation has

occurred. This phenomenon is called ionisation isomerism. An example of a pseudo acid is nitroform. $HC(NO_2)_3$.

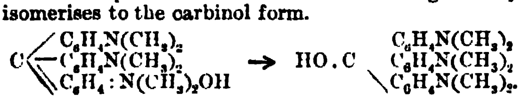
Pseudo Acid. Constitution of Hypothetical Acid which yields the Ions. Salt.

The pseudo acid is a colourless crystalline solid which melts at 15°; in non-ionising solvents (benzene, chloroform, dry ether) it gives colourless solutions, but in presence of water the solution turns yellow, and its conductivity shows it to be a very strong acid. Other examples of pseudo acids are the acid amides

$$R.CO.NH_2 \rightarrow R.C{:}NH \atop \quad OH$$

(Acid from which Salts are derived.)

the nitro- and isonitro-compounds (*see* NITRO COMPOUNDS), the keto-enol compounds (*see* ETHYL ACETOACETATE). Pseudo acids are distinguished in several ways; thus their aqueous solutions neutralise a base gradually, that is as the pseudo acid isomerises; also they have an abnormally great temperature coefficient of conductivity and an abnormally great variation of dissociation with variation of temperature. They do not form salts with dry ammonia in a non-dissociating solvent, but they do so in presence of water. Pseudo bases are substances which in themselves are electrically indifferent, but are isomeric with ammonium hydroxides, and can pass into these, forming ammonium salts. Examples are the ammonium hydroxides of the acridine and quinoline series and a number of colour bases; *e.g.* when caustic soda is added to the hydrochloride of hexamethylpararosaniline, a strongly dissociated alkaline hydroxide is formed which gradually isomerises to the carbinol form.



Pseudo-Dipteral (*Architect.*) A temple having only one range of columns at each side, but the distance of these columns from the side walls is the same as if there had been two ranges. *See* DIPTERAL.

Pseudoisatin (*Chem.*) *See* ISATIN.

Pseudomorphism (*Min.*) The assumption by one mineral of the form of another. It may occur by the pseudomorphous mineral coating the original, or by the one infiltrating a cast left by the other on its decomposition, or by a gradual replacement of one mineral by another, or, lastly, by some chemical change occurring in the original mineral without change of form.

Pseudo-Peripteral (*Architect.*) A temple somewhat resembling a peripteral temple, but attached columns are used on one side or more instead of a series of detached columns. *See* PERIPTERAL.

Psilomelane (*Min.*) Hydrous manganese manganate, H_4MnO_5: not crystallised; occurs in mammillated masses of black colour. It contains 70 to 80 per cent. of the oxides of manganese, and nearly always some barium. It is often associated with other manganese ores, and may occur in any of their localities.

Psychrometer (*Meteorol.*) An instrument for determining the relative humidity of the atmosphere by the temperature of evaporation. It consists of two similar thermometers, the bulb of one being covered by thin muslin connected to a wick dipping into water.

Pt (*Chem.*) The symbol for PLATINUM (*q.v.*)

Ptera (*Architect.*) The ranges of columns surrounding a Grecian temple. *See* PERISTYLIUM.

Pteroma (*Architect.*) Spaces between the side walls or pteromata of a temple and the range of columns surrounding it.

Pteromata (*Architect.*) The side walls of a Grecian temple. *See* PTEROMA *and* PTERA.

Ptomaines (*Chem.*) A name given by Selmi to substances obtained from corpses which have basic properties show the general reactions of the plant alkaloids, but are not identical with any of these, and some of which are poisonous. A knowledge of their properties and the methods of isolating them is very important in some cases of poisoning, as cases have arisen in which persons have been suspected of administering an alkaloid when death has really been caused by ptomaine poisoning. Ptomaines arise in several distinct ways: (1) In flesh, by the process of putrefaction; (2) as products of the action of bacteria, the bacteria being contained in the flesh, but not producing ptomaines until the flesh is eaten; (3) in certain shell fish, such as the mussel, when it lives in water contaminated by sewage or in stagnant water. Chemically, ptomaines belong to very different classes of compounds. Some are derivatives of ammonium hydroxide (*see* CHOLINE, MUSCARINE, *and* NEURINE); others are diamines (*see* CADAVERINE *and* PUTRESCINE); others are pyridine derivatives, and many are of unknown constitution, as, for example, the substance called mytilotoxine, $C_6H_{15}NO_2$, which is believed to be the mussel poison; and the substance called tyrotoxicon, which does not give the alkaloid reactions, but resembles diazobenzene in its poisonous action, and which is obtained from cheese. The mode of origin of some ptomaines is intelligible. Choline, neurine, muscarine, betaine, and trimethylamine all arise from LECITHIN (*q.v.*)

Lecithin → Choline (Hydrolysis) ↗ Neurine (by dehydration) → Muscarine (by oxidation) ↘ Betaine (by oxidation) → Trimethylamine.

Arginine is a decomposition product of proteids, and it yields ornithine on hydrolysis, which in turn can yield putrescine.

$$HN{:}C\genfrac{}{}{0pt}{}{NH_2}{NH}.CH_2.CH_2.CH_2.CHNH_2.COOH$$
Arginine.

$$\rightarrow CH_2NH_2.CH_2.CH_2.CHNH_2.COOH$$
Ornithine.

$$\rightarrow CH_2NH_2.CH_2.CH_2.CH_2NH_2.$$
Putrescine.

Lysine, another decomposition product of proteids, might yield cadaverine, just as ornithine yields putrescine:

$$CH_2NH_2.CH_2.CH_2.CH_2.CHNH_2.COOH$$
Lysine.

$$\rightarrow CH_2NH_2.CH_2.CH_2.CH_2.CHNH_2.$$
Cadaverine.

The method of extracting ptomaines is as follows (Brieger's): The substance is slightly acidified with hydrochloric acid, and evaporated to a syrup on a water bath; the syrup is extracted with alcohol,

and a solution of mercuric chloride in alcohol added to the extract. This precipitates the ptomaine as a double salt with mercuric chloride, and this double salt is extracted from the precipitate by hot water. The procedure now depends on the ptomaine present; *e.g.* the double hydrochloric of choline and mercury, if present, will crystallise from the hot solution, while all others remain in solution. The mercury is precipitated from the solution by sulphuretted hydrogen, and the filtrate evaporated to dryness. On extracting the residue with hot alcohol, hydrochlorides of diamines, such as putrescine and cadaverine, remain behind, and so on. The symptoms of ptomaine poisoning are not always the same, but vomiting, purging, prostration, and cramp in the legs are common. A difficulty in the detection of ptomaines arises from the fact that they are only intermediate stages in a long series of decompositions of complex substances, so that they may be present for a few days only, then disappear.

P-Trap (*Build.*) A trap resembling the letter P, having a nearly horizontal outlet.

Ptyalin (*Chem.*) *See* DIASTASE.

Pucella (*Glass Manufac.*) A spring tool: the principal tool of the glass maker. In form somewhat like sugar tongs with the sides flattened at a right angle to the spring and tapering to a point.

Puddled Ball (*Met.*) The mass of puddled iron withdrawn from the furnace.

Puddled Bar (*Met.*) The bars of wrought iron when they leave the rolling mills.

Puddlers' Mine (*Met.*) A mixture of ground hæmatite and water, used in lining puddling furnaces.

Puddling (*Eng.*) (1) Mixing clay with water, either for making a plastic mass or to aid the separation of stones and grit from the clay, as in brickmaking. (2) Filling or lining a space with clay to render it watertight; *e.g.* a cofferdam is made watertight by ramming clay behind the boards. (3) The clay used in the latter operation is itself termed Puddling.

—— (*Met.*) The conversion of brittle pig iron into malleable iron by decarburising the former and removing silicon, phosphorus, sulphur, etc., by atmospheric oxidation. *Cf.* PIG BOILING. *See also* IRON.

Puddling Furnace (*Met.*) A reverberatory furnace in which the operation of puddling is carried on. *See* FURNACES.

Puer (*Leather Manufac.*) A bate of animal dung used for softening hides.

Puering (*Leather Manufac.*) Skins after liming, unhairing, and fleshing are steeped in a fermenting solution of excrement. This process is termed PUERING (*puer*, to stink) when dog excrement is used; bating when the excrement of fowls is employed. *See* BATING.

Pugging (*Build.*) Rough plaster or slag wool laid between the joists of a floor to form a filling and render the floor sound proof.

Pug Mill. A mill used for mixing clay for bricks, materials for making concrete, etc. *See* BRICKS.

Pulley. (1) A general term for a small wheel. (2) A wheel on a shaft driven by or driving a belt.

Pulley Block. A wood or metal frame carrying one or more grooved pulleys over which ropes or chains run.

Pulley Style (*Carp. and Join.*) One of the uprights into which the pulleys are fixed to carry the sashes and weights in a cased frame.

Pulling Up (*Foundry*). The tearing of the sand of a mould whilst the pattern is being withdrawn from the mould.

Pulpit. An elevated enclosed stage in a church from which the preacher delivers his sermon.

Pulp Saver (*Paper Manufac.*) An apparatus for recovering small particles of pulp from surplus backwater.

Pulse (*Botany*). A general term for the seeds of the order *Leguminosæ*, *e.g.* Beans, Peas, and Lentils.

—— (*Music*). *See* BEAT.

Pulvinated (*Architect.*) A pulvinated frieze is one which has a convex face.

Pumice (*Geol.*) Strictly, speaking this term should be restricted in its scientific application to the volcanic froth which has been formed at the surface of a liquid lava of acid composition, and which has been blown into the air from the crater from time to time while small explosions of steam were rising through the fluid mass. These frothy ejections, full of vapour cavities, but consisting essentially of volcanic glass or obsidian, have in many cases fallen back outside the crater, and have thus contributed to the growth of the volcanic cone. The best pumice is obtained from the Lipari Island, mostly from the Campo Bianco.

Pumicestone (*Dec.*) Pumice has important use in painting, by assisting in the production of level surfaces and by reducing inequalities. It is used with water, and is first rubbed flat on one side, so as to prevent scratching. Carriage painters more frequently use specially made pumice composition blocks. Powdered pumice is employed with a felt rubber and water to rub down certain varnished surfaces, and in order to get a perfectly smooth ground for subsequent coats of varnish

Pumping Engine. An engine specially fitted for driving pumps for any purpose. Very large engines are used in mines for drawing off the water from the workings, and it was in this connection that steam engines were first used. Many large pumping engines are beam engines, following the type of the early steam engines.

Pumps. The principle of the common LIFT PUMP is shown in fig. 1. A piston or BUCKET A fits smoothly in the BARREL B, and is raised and lowered by the rod C. A pipe E dips into the water to be raised. As the piston is raised a partial vacuum is produced in the barrel, and water rises in the pipe E, passing through the FOOT VALVE D as soon as the pressure of the air in the barrel has been sufficiently diminished. When the piston descends, D closes, and the valve F, termed the BUCKET VALVE, opens, and allows the water to pass through the opening into the space above the bucket. When the piston rises again, F closes, and the water is lifted until it flows out of the spout G. The actual height to which water can be

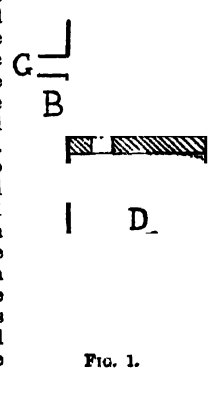


FIG. 1.

drawn is about 25 ft., measured from the level of the water in the reservoir below the pump to the position of the bucket when at the highest point of its stroke. When water has to be raised through a greater height than this, some form of FORCE PUMP (fig. 2) is used. The piston or PLUNGER of this pump is solid. The action during the ascent of the piston is similar to that of the lift pump; but as the piston descends, the water is forced through a valve A and up the pipe B. The height to which the water can be forced now depends only upon the force which is applied to the piston or plunger during the downstroke.

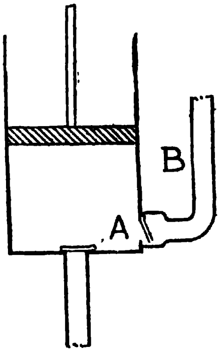


FIG.

The discharge from a force pump may be made continuous by the use of an air vessel (fig. 3). Water enters the chamber A through B, and escapes through the pipe C, whose diameter is so adjusted that during the downstroke of the pump the water enters through B more rapidly than it can escape through C. As a consequence, the air in the space D is compressed, and the water in A is under considerable pressure at the end of the downstroke. This pressure causes the water to flow through C after the downstroke ceases, and, if the vessel be of sufficient size, this flow will become continuous. Many modern types of pump driven by power are constructed on the principle of the force pump. Some of these are double acting. An inlet and an outlet are provided at each end of the barrel, so that the flow of water through the pump is analogous to the movement of the steam in the cylinder of a steam engine. A totally different principle is used in the CENTRIFUGAL PUMP. The moving portion consists of a number of curved blades mounted on an axle, by which they are set in rapid rotation. This part, or FAN, is contained in a circular casing, provided with inlets at the centre and a wide outlet at the circumference, running in a tangential direction. The water fills the casing, and is set in rotation by the blades; centrifugal force drives it outward, and it flows through the discharge pipe in a steady stream, while fresh water is continually drawn into the casing through the inlet pipe. A centrifugal pump is not suited to very high lifts, and it only works with its maximum efficiency at the one lift for which it was designed.

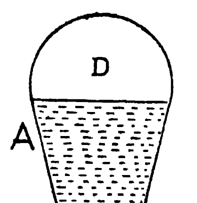


FIG. 3.

Puna Winds (*Meteorol.*) Very dry winds which pass over the barren tableland, called the Puna, to the east of Arequipa in Peru. These winds are parched to a degree that has perhaps no parallel in any other country.

Punch. A steel tool used for forming holes in thin metal, etc., by driving the point through with blows from a hammer; also for a great variety of purposes apart from this use, *e.g.* used by carpenters and joiners for driving the heads of nails below the surface of woodwork.

Punched Holes (*Eng.*) Commonly used in riveted work, such as boilers, girders, etc. The holes are usually made by a punching machine, but the plate is apt to be weakened by punching, and drilled holes are preferable.

Punching (*Masonry*). Dressing masonry with a tool known as a punch.

Punching Machine (*Eng.*) A machine for driving a large punch by power; used in all boiler shops, etc.

Punta (*Music*). The point, as *colla punta dell' arco*, with the point of the bow.

Purbeck Beds (*Geol.*) Rocks of fluviomarine origin, in Britain, which occupy a position intermediate between the Wealden Strata and the Portland Rocks, and, according to many British authors, forms, with them, the uppermost Jurassic Rocks. At and near Purbeck these strata have yielded an exceedingly interesting suite of mammalian fossils which otherwise would have remained almost entirely unknown.

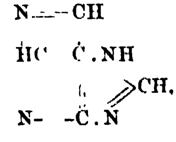
Purchase. A term signifying leverage.

Purification of Sewage (*Civil Eng.*) Sewage is purified by processes which may be classified in a manner similar to those adopted for the purification of water. The presence of the grosser part of the sewage may be very largely dealt with by settling tanks, but bacteriological methods are gaining ground. *See* SANITATION, SEPTIC TANK SYSTEM, *and* SEWAGE; *also* FILTERS, FILTRATION.

Purification of Water (*Civil Eng.*) This is effected by three means: (1) Mechanical, *e.g.* by LEAPING WEIRS (*q.v.*), SETTLING TANKS (*q.v.*), or by simple filtration. (2) Chemical means, *e.g.* by Clark's Process for softening water. (3) Bacteriological means. Bacteria and other organisms have a great effect in the purification of water, the conditions of which are very complex and not completely understood.

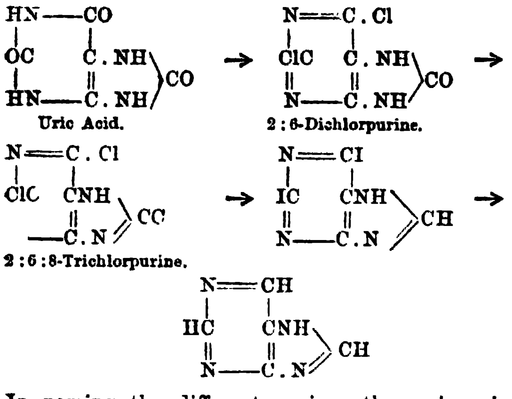
Purifiers (*Gas Manufac.*) *See* GAS MANUFACTURE.

Purines (*Chem.*) Are derivatives of PURINE

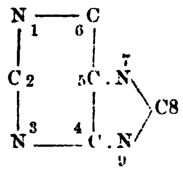


a white solid, crystallising in minute needles from toluene; melts at 216° to 217°, and volatilises on further heating, with partial decomposition; very soluble in water; neutral reaction, but forms salts with acids, behaving as a monacid base. It is stable towards oxidising agents, and thus does not yield the murexide test (*q.v.*) It is obtained from uric acid by converting it into the potassium salt, acting on this with phosphorus oxychloride at 160° to 170°, and treating the dichlorpurine so obtained with the same reagent at 150° to 155°, obtaining 2:6:8-trichlorpurine. The trichlorpurine heated with hydriodic acid and phosphonium iodide at 0° yields 2:6-diiodopurine, which, on boiling with zinc dust and water in a stream of carbon dioxide, gives purine as an insoluble zinc compound. The latter is decomposed by boiling with water and passing in sulphuretted

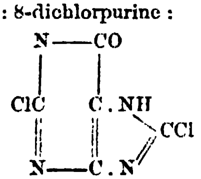
hydrogen: on filtering and concentrating in a vacuum the purine crystallises out.



In naming the different purines the purine ring is numbered as shown in the diagram:



Examples: uric acid is 2 : 6 : 8-trioxypurine. The 2 : 6 : 8-trichlorpurine mentioned above crystallises in plates which contain five molecules water of crystallisation, and is soluble in 70 parts of hot water. It is an important starting point in the synthesis of a number of purine derivatives. When heated with a normal solution of caustic potash it yields 6-oxy-2 : 8-dichlorpurine:



from which guanine, hypoxanthine, and xanthine can be synthesised. *See these.* Hypoxanthine is obtained from 6-oxy-2 : 8-dichlorpurine by reduction with hydriodic acid. The four purine bases adenine, guanine, hypoxanthine, and xanthine are decomposition products of the nucleic acids. Adenine is 6-aminopurine, and it can be obtained from 2 : 6 : 8-trichlorpurine by the action of aqueous ammonia, which yields 6-amino-2 : 8-trichlorpurine, and hydriodic acid reduces this to adenine. The purines caffeine (*q.v.*), guanine, hypoxanthine, theobromine (*q.v.*), and xanthine occur in food stuffs—hence the importance of a careful diet in those suffering from uric acid diseases. Meat, certain vegetables, such as peas, beans, lentils, and asparagus; tea, coffee, cocoa, and beer all contain purines; but milk, butter, cheese, eggs, and white bread contain very little purines. Wines contain no purines.

Purlins (*Build.*) The horizontal beams that support the common rafters. *See* ROOFS.

Purple Brown (*Dec.*) The popular name for purple oxide (*q.v.*) It may be imitated by adding a little ultramarine and lampblack to Indian red.

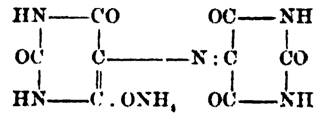
Purple of Cassius (*Chem.*) *See* TIN COMPOUNDS.

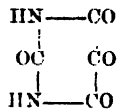
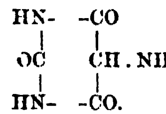
Purple Oxide (*Dec.*) A dark reddish purple pigment consisting almost wholly of artificially made ferric oxide. It makes a cheap and serviceable paint, and is usually sold as Purple Brown.

Purpose Made (*Build.*) The term applied to bricks, etc., made to a given pattern.

Purpure (*Her.*) Purple, a tincture rarely used in English heraldry. Represented by diagonal lines from left to right. *See under* HERALDRY.

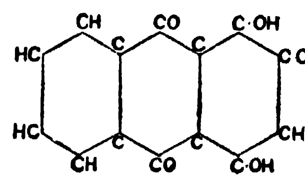
Purpuric Acid (*Chem.*) Not known in the free state. When an acid is added to any of its salts, the purpuric acid decomposes into alloxan and amidobarbituric acid (uramil). Ammonium purpurate, commonly called murexide, is its most important salt:



It crystallises in red prisms, which show a fine green lustre by reflected light; sparingly soluble in cold water, much more soluble in hot water; insoluble in alcohol and ether; decomposed by acids into alloxan,  and uramil, 

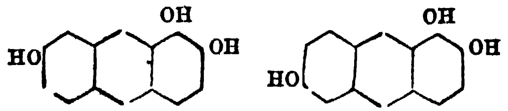
Caustic potash turns its solution blue. It is obtained by evaporating uric acid with nitric acid, and adding ammonia to the residue (murexide test); by mixing ammonia solutions of alloxan and uramil; by boiling uramil with ammonia and mercuric oxide. Formerly it was much used as a dye, and it is still so used to a small extent.

Purpurin (*Chem.*)



(1 : 2 : 6-trioxyanthraquinone). Crystallises from aqueous alcohol in orange coloured prisms which contain one molecule water of crystallisation. Becomes anhydrous at 100°; sublimes on heating and melts at 253°; soluble in alcohol and ether; slightly soluble in hot water. Dissolves in alkalis, forming a red solution, which is oxidised on exposure to air, turning yellow and yielding phthalic acid. Dissolves in a boiling solution of alum, forming a pink solution with yellow fluorescence. With an alum mordant it dyes a beautiful scarlet red. It is oxidised by nitric acid to phthalic acid; heated with zinc dust it is reduced to anthracene. It occurs with alizarin (*q.v.*) in madder root. It is obtained from alizarin by oxidation with manganese dioxide and sulphuric acid at 150°. Isopurpurin, also called anthrapurpurin, is isomeric with purpurin. Flavo-

purpurin is also isomeric with purpurin. Both isomers are also used as dyes.



Isopurpurin. Flavopurpurin.

Push (*Elect. Eng.*) A contact maker actuated by a stud which is pushed in by the finger; when released it is forced out again by a spring and breaks the circuit.

Putlog (*Build.*) One of the bearers or horizontal members that carry the boards of a scaffold. *Cf.* LEDGERS.

Putrefaction in Meat (*Foods*). This is caused by the presence of putrefactive bacteria, the ferments generated by which give rise to poisonous substances unaffected by cooking. *See* FOODS.

Putrescine (*Chem.*) (Tetramethylenediamine),

$$\begin{array}{l} CH_2 . CH_2 . NH_2 \\ | \\ CH_2 . CH_2 . NH_2 \end{array}$$

A colourless liquid with peculiar smell. Boils at 158° to 160°; soluble in water; difficultly volatile in steam; strong alkali, absorbing carbon dioxide from the air forming the carbonate, and uniting with acids to form salts which are all crystalline. It gives precipitates with all the alkaloid reagents (*q.v.*), and forms a characteristic urea by direct union with phenylisocyanate in dry ether. With benzoyl chloride and caustic soda (Baumann-Schotten reaction, *q.v.*) it yields a dibenzoyl compound—

$$(CH_2)_4 \left< \begin{array}{l} NHCOC_6H_5 \\ NHCOC_6H_5 \end{array} \right.$$

which melts at 175°, and is insoluble in water or ether. Putrescine is not very poisonous. It is one of the ptomaines (*q.v.*), and occurs in putrefying flesh of men and animals, also in pure cultures of the cholera bacillus and occasionally in urine. It can be obtained synthetically by reduction of ethylene cyanide in alcoholic solution by means of sodium:

$$\begin{array}{lllllll} CH_2 & \rightarrow & CH_2Br & \rightarrow & CH_2CN & \rightarrow & CH_2 . CH_2 . NH_2 \\ \| & & | & & | & & | \\ CH_2 & Br & CH_2Br & KCN & CH_2CN & H & CH_2 . CH_2 \;\; NH_2 \end{array}$$

Ethylene. Ethylene bromide.

When pyrrole (*q.v.*) is acted on by hydroxylamine it yields the oxime of succinic aldehyde, which on reduction gives putrescine:

$$\begin{array}{lll} H_2C - CH : NOH & & H_2C - CH_2 . NH_2 \\ | & & \\ H_2C - CH : NOH & H & H_2C - CH_2 . NH_2 \end{array}$$

For a probable explanation of its origin by putrefaction, *see* PTOMAINES.

Putty (*Dec.*) Painters' putty is used for stopping or bringing to a level surface nail holes, abrasions, and other defects in wood or iron work prior to painting or repainting. It is made by mixing whiting with raw linseed oil. The whiting must be free from grit, quite fine, and dry, and the oil should be pure linseed oil only. The admixture is effected in a pug mill or in an ingenious mixer, which is largely employed also by bakers for mixing dough. Sometimes linseed oil foots (*q.v.*) are used, and for putty that is exported to hot countries it is usual to add a little cotton seed oil to retard the drying. Putty is also largely used for glazing windows; but for this purpose an addition of one-tenth part of white lead to the whiting increases the durability of the putty, and is almost a necessity when glazing in exposed positions—such, for instance, as the roof of a greenhouse or conservatory.

Putty (*Build.*) Plasterers' putty is thin mortar, *i.e.* mortar with a considerable quantity of water added.

Putty Joint (*Plumb.*) A joint made with red and white lead covered with a piece of rag and bound with string.

Putty Powder (*Glass Manufac.*) Stannic Oxide. *See* TIN COMPOUNDS.

Puy (*Geol.*) A provincial term in use in the Auvergne district (and elsewhere) for the isolated volcanic cones which form so conspicuous a feature in the scenery of that part. The use of the term has now been extended so as to apply to the local accumulations arising from any small volcano, in contradistinction to the more widely extended volcanic products which come from great volcanic aggregates like those of Hawaii, Iceland, and others.

Pycnostyle (*Architect.*) The name given to the spacing of the columns in a Grecian temple when the space between the columns is equal to one and a half times the lower diameter of the shaft. *See* SYSTYLE, EUSTYLE, ARÆOSTYLE, DIASTYLE, *and* INTERCOLUMNIATION.

Pylon (*Architect.*) A structure of the shape of an oblong truncated pyramid placed on each side of the entrance to an Egyptian temple.

Pynkometer (*Phys.*) A vessel which is filled up to a definite mark with any given liquid in order to compare the specific gravity (*q.v.*) of one liquid with that of another. The commonest form is a small flask provided with a stopper pierced by a small hole; the flask is nearly filled with the liquid, and the stopper is inserted, when the superfluous liquid rises through the hole and can be removed by wiping the flask. The whole is now weighed, and the operation repeated with a different liquid. Deducting the weight of the empty flask, we obtain the weights of two equal volumes of the different liquids. This form is usually termed a SPECIFIC GRAVITY FLASK.

Pyramid. A solid whose sides are triangles having a common vertex, and whose bases form the sides of a polygon, termed the BASE of the pyramid.

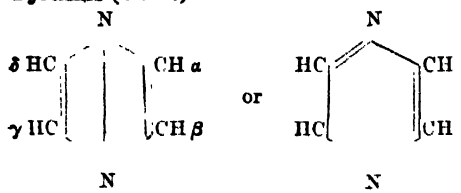
—— (*Archæol., etc.*) A structure, generally of stone, with a square base and triangular sides, the latter meeting in an apex. The most notable examples are the pyramids of Egypt, especially those at Gizeh. The Great Pyramid over the tomb of Cheops stood on a base 756 feet square, and rose to a height of 481 feet.

—— (*Min.*) A closed crystalline form, whose faces cut three axes; the faces are in two symmetrical groups, one group on either side of a plane or base whose outline is determined by the crystalline system to which the pyramid belongs.

Pyrargyrite (*Min.*) One of the Red Silver Ores or Ruby Silvers. *See* PROUSTITE. Sulphantimonite of silver, $3Ag_2S . Sb_2S_3$. Silver = 59·8, sulphur = 17·7, antimony = 22·5 per cent. Rhombohedral and hemi-

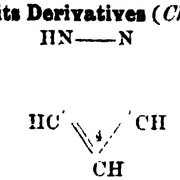
morphic. It is rich dark red by transmitted light; by reflected light almost black, with a submetallic lustre. Chiefly from the Harz Mountain mines.

Pyrazine (*Chem.*)

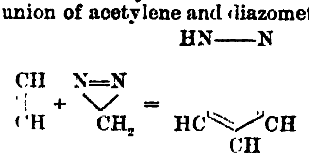


A solid crystallising in colourless prisms. Melts at 52°; boils at 118°; sublimes at the ordinary temperature; smells like heliotrope; its vapour burns with a reddish flame. It is a weak base; it combines with many salts to form double compounds, *e.g.* $C_4H_4N_2HgCl_2$. It is formed by distilling piperazine, which is hexahydropyrazine, with zinc dust; also by heating pyrazine carboxylic acids which lose carbon dioxide and yield pyrazine; also by heating amino-acetaldehyde with a solution of mercuric chloride. Methyl pyrazines are probably among the products obtained when dextrose is heated with a solution of ammonia under pressure. The *a*, *γ*-dimethylpyrazine is formed when glycerine is distilled with ammonium salts (mixture of chloride and phosphate), and it occurs in some fusil oils. The methyl pyrazines are oxidised to carboxylic acids by potassium permanganate.

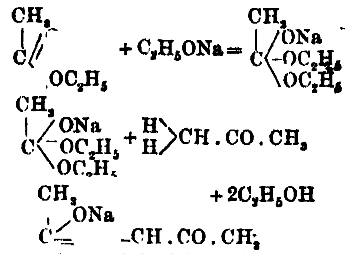
Pyrazole and its Derivatives (*Chem.*) PYRAZOLE,



A colourless solid crystallising in long needles; melts at 70°; boils at 185°; soluble in water, alcohol, ether. In its chemical behaviour it resembles both pyridine and benzene, the former in combining with metallic chlorides such as mercuric chloride, and, in the property of its hydrochloride, combining with platinic chloride, and also in the fact that the 1-alkyl pyrazoles smell like pyridine, and both pyrazole and pyridine are weak bases. It resembles benzene in the stability of the ring towards oxidising and reducing agents; with strong sulphuric acid it forms a sulphonic acid; with strong nitric acid it forms a nitro-compound (NO_2 at 4°), which can be reduced to an amido-compound, and the latter undergoes the diazo-reaction, etc. Pyrazole behaves as a secondary base. With ammoniacal silver nitrate it gives a white precipitate of silver pyrazole, the silver displacing the hydrogen at the nitrogen atom; with acid chlorides the same hydrogen is replaced by the acid radical. Pyrazole can be obtained: (1) By direct union of acetylene and diazomethane:

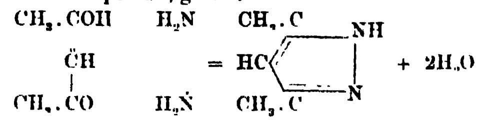


(2) By the following, which is a particular case of a general reaction which is patented by Knorr from the acetyl acetone stage onwards. Ethyl acetate and acetone undergo condensation with sodium or sodium ethoxide:



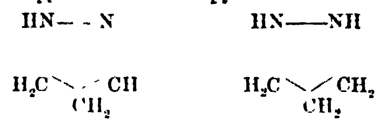
Sodium Salt of Acetyl Acetone.

The acetyl acetone, on treating with hydrazine sulphate and caustic potash, gives:



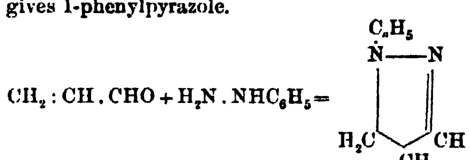
3 : 5 - dimethylpyrazole.

The 3 : 5-dimethylpyrazole, on oxidation with potassium permanganate, gives the corresponding dicarboxylic acid, which goes smoothly into pyrazole on heating. Pyrazole derivatives are named by mentioning the substituting group and its position in the numbered ring. Also the following names must be noticed: Dihydropyrazole is called pyrazoline, and tetrahydropyrazole is called pyrazolidine.



Pyrazoline B.P. 144°. Pyrazolidine (not obtained).

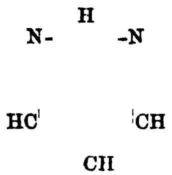
When two hydrogens attached to the same carbon atom are replaced by an oxygen atom, thus giving a ketone group, the termination "-ine" is changed to "-one." Examples below. PYRAZOLE HOMOLOGUES are obtained in various ways: (1) By action of an alkyl iodide on the silver compound of pyrazole. (2) By the second reaction for the preparation of pyrazole given above, which is a general reaction; *e.g.* instead of using hydrazine, substituted hydrazines can be employed. (3) By transposition of the methyl iodide compound of other pyrazoles. The following homologues are important: 1-phenylpyrazole; a liquid boiling at 246° is formed from epichlorhydrin and phenylhydrazine, or from acrolein and phenylhydrazine, when a phenylpyrazoline is first formed, which easily loses hydrogen and gives 1-phenylpyrazole.



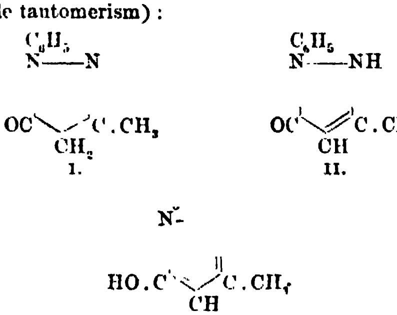
1-phenylpyrazoline.

1-phenylpyrazole combines with methyl iodide, and the compound so formed when heated yields 1-phenyl-4-methylpyrazole, the methyl group leaving the nitrogen and wandering to position 4. Two isomeric phenylmethylpyrazoles, *viz.* 1-phenyl-3-methyl and 1-phenyl-5-methyl, are obtained by the condensation of oxymethylene acetone ($CH_3COCH : CHOH$, by condensation of ethyl formate and acetone by sodium

ethoxide) and phenyl hydrazine. On oxidation, both isomers yield *the same* compound, namely 3-methylpyrazole. The same methylpyrazole is obtained by condensation of oxymethylene acetone and hydrazine. *Hence it appears that the positions* 3 *and* 5 *in the pyrazole ring are equivalent.* It is concluded that the imide hydrogen is labile, and belongs equally to the two nitrogen atoms; to express this the formula for pyrazole is often written

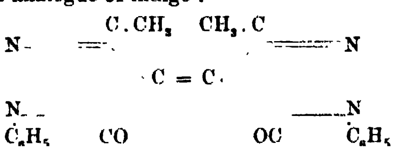


1-PHENYL-3-METHYL-5-PYRAZOLONE. This is the compound formed by the action of phenylhydrazine on ethylacetoacetate (*q.v.*) and treatment of the product with caustic potash; it melts at 127°, and is prepared on a large scale for the manufacture of antipyrine. Although it is known in one form only, it reacts as if it could assume three different formulæ (double tautomerism):

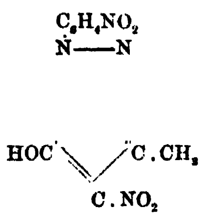


I. II. III.

Examples: According to I. (methylene form), when it is oxidised by ferric chloride to pyrazole blue, the pyrazole analogue of indigo:

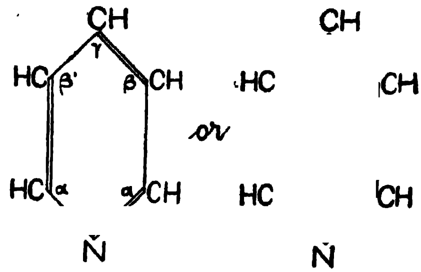


According to II. (imine form), in antipyrine (*q.v.*), which is 1-phenyl-2:3-dimethyl-5-pyrazolone. According to III. (phenol form), in picrolonic acid, which is 1-paranitrophenyl-3-methyl-4-nitro-5-pyrazolone:

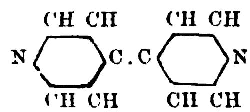


This acid is the picric acid of the pyrazole series, and is obtained by nitration of 1-phenyl-3-methylpyrazoline; like picric acid, it forms numerous sparingly soluble salts with bases, and lately has been used as a reagent in the isolation and characterisation of

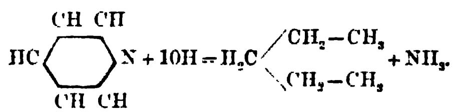
Pyridine (*Ch m.*)



A colourless liquid; characteristic unpleasant smell; poisonous; boils at 115°; soluble in water, alcohol, etc.; it is a base forming salts with acids, *e.g.* $C_5H_5N . HCl$; this hydrochloride unites directly with platinic chloride, forming $(C_5H_5NHCl)_2PtCl_4$, which on prolonged boiling with water forms the yellow insoluble compound $\left\{Pt(C_5H_5N)_2Cl_2\right\}Cl_2$; it also unites with mercuric chloride to form double salts, such as $C_5H_5NHCl2HgCl_2$. It is a tertiary base, uniting directly with alkyl iodides. *See* below. With metallic sodium at 80° it forms γ, γ-dipyridyl

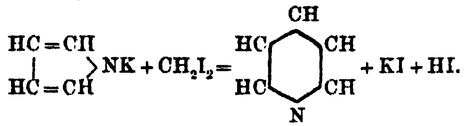


and other products. With sodium and alcohol it yields piperidine (*q.v.*) Heated with hydriodic acid at 300°, it yields normal pentane and ammonia:

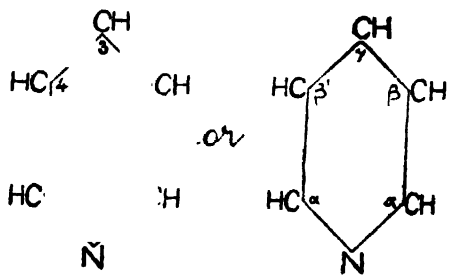


The pyridine ring is very stable, and pyridine is not attacked by boiling concentrated nitric acid nor by chromic acid; ordinary concentrated sulphuric acid does not attack it, but fuming sulphuric acid forms β-pyridine sulphonic acid. Pyridine does not readily give halogen substitution products with the halogens directly: these are obtained by indirect means, *e.g.* by heating pyridine with phosphorus pentachloride, which yields $\alpha\alpha'$ dichlorpyridine. Pyridine and its homologues occur in coal tar, in bone oil, and in shale oil. Pyridine has also been found in tobacco smoke and in the smoke laden air of towns. It is obtained from coal tar. To extract it the tar is distilled, and that fraction which comes over between 60° and 150° is shaken with strong sulphuric acid; the sulphuric acid extract is then heated to boiling to expel neutral substances, and, after cooling, caustic soda is added. The basic oil which separates is purified by fractional distillation; in this way an impure pyridine is obtained which may be purified by adding mercuric chloride to its solution in hydrochloric acid, crystallising the double salt, and distilling it with caustic soda. Pyridine is largely used as a solvent; during the last few years it has been very largely used, especially abroad, for mixing with alcohol to render it undrinkable. Interesting laboratory methods of obtaining pyridine are: (1) By

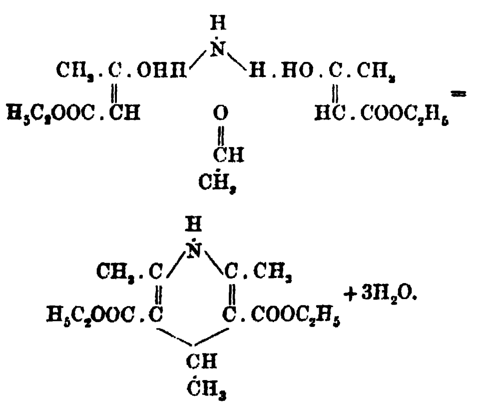
heating pyridine carboxylic acids with soda lime, just as benzene is obtained from benzene carboxylic acids. (2) By heating the potassium compound of pyrrole with methylene iodide:



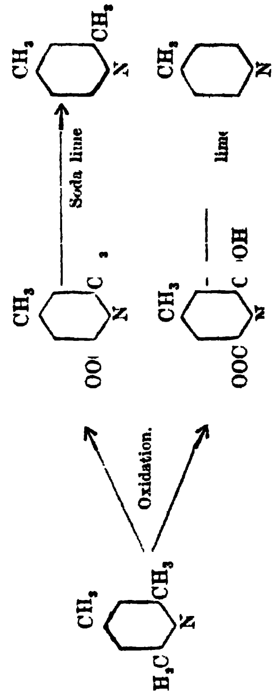
Similarly, β-chlorpyridine is obtained if chloroform be used in place of methylene iodide. (3) By heating piperidine (*q.v.*) with concentrated sulphuric acid. Pyridine derivatives are named by numbering the carbon atoms of the ring or by denoting the carbon atoms by a letter:



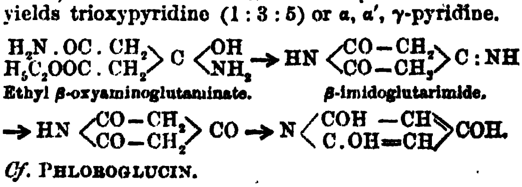
As the carbon atoms 1 and 5 are similarly situated, in lettering the ring these positions are indicated by the same letter, and when both positions are occupied one letter is distinguished by a dash; similar remarks apply to the positions 2 and 4. It is useful to remember that the positions α and γ are similar to the ortho- and para-positions in benzene, while the β position is similar to the meta-position in benzene. HOMOLOGUES OF PYRIDINE: The monomethyl pyridines are called PICOLINES, and are distinguished as α-picoline, β-picoline, γ-picoline; the dimethyl pyridines are called LUTIDINES; the trimethyl pyridines are called COLLIDINES. A very important pyridine synthesis, and one by means of which a number of these homologues may be obtained, consists in heating together ethyl acetoacetate (52 grs.) and aldehyde-ammonia (15 grs.):



The ethyl dihydrocollidinedicarboxylate so formed readily loses two atoms of hydrogen on reduction by nitrous acid, and on treating the product with caustic potash it is hydrolysed, yielding collidine dicarboxylic acid. This acid, on heating with soda lime, yields collidine (αα′γ-trimethylpyridine).

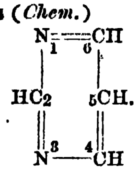


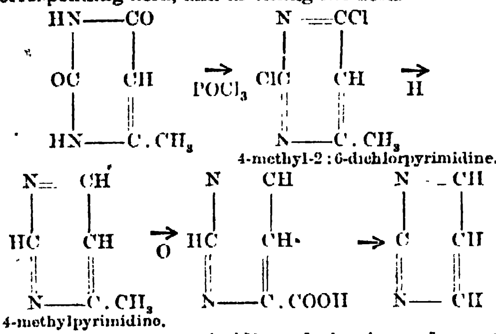
The synthesis can be varied by using other aldehyde ammonias, and in place of one molecule of ethyl acetoacetate, other ketonic acids or 1 : 3-diketones. Pyridine homologues are also obtained by heating alkyl iodide compounds of pyridine, when the alkyl group leaves the nitrogen and wanders into the nucleus, the γ-position being occupied first, then the α-position. The β-position is never occupied in this kind of transposition (similarity to benzene ring). All homologues of pyridine on oxidation yield pyridine carboxylic acids. PYRIDINE CARBOXYLIC ACIDS: Some of these are important as products obtained by breaking down several alkaloids; *e.g.* NICOTINIC ACID from nicotine is 2-pyridine carboxylic acid. CINCHOMERONIC ACID from cinchonine is 2 : 3-pyridine carboxylic acid. Quinolinic acid, obtained by oxidation of quinoline, is the 1 : 2-pyridinecarboxylic acid. HYDROXYPYRIDINES: The α- and γ-hydroxypyridines have the property of behaving like ketones, as well as like hydroxy-compounds. On this account they are also called PYRIDINES. Examples: If the ethyl ester of acetone dicarboxylic acid (from citric acid by the action of strong sulphuric acid) be heated with ammonia, it forms the ethyl ester of β-oxyaminoglutaminic acid, which, when treated with an alkali, forms β-iminoglutarimide, and this with concentrated hydrochloric acid yields trioxypyridine (1 : 3 : 5) or α, α′, γ-pyridine.



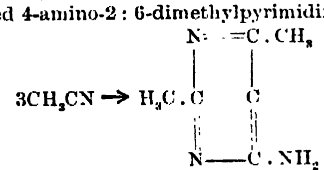
Cf. PHLOROGLUCIN.

Pyrimidines (*Chem.*)

PYRIMIDINE.  A white solid; melts at 20° to 22°; boils at 124°; has penetrating and narcotic smell; soluble in water, giving a neutral solution; yields crystalline, sparingly soluble double salts with mercuric and gold chlorides. It is obtained from methyl uracil (*see* ETHYL ACETOACETATE) by heating it with phosphorus oxychloride, reducing the methyldichlorpyrimidine so obtained with zinc dust and water, oxidising the resulting methylpyrimidine with dilute potassium permanganate solution to the corresponding acid, and distilling the acid.



There are three pyrimidine derivatives of great importance in the chemistry of the proteids. They are: URACIL or 2 : 6-dioxypyrimidine; THYMIN or 5-methyl-2 : 6-dioxypyrimidine; CYTOSIN or 6-amino-2-oxypyrimidine. These are all crystalline solids obtained by decomposition of nucleic acids. Uracil was first obtained from yeast, thymin from the thymus gland, and cytosin from the same source. Pyrimidines are also obtained where nitriles are caused to polymerise under the influence of metallic sodium or sodium ethoxide. Thus from acetonitrile is obtained 4-amino-2 : 6-dimethylpyrimidine —



Pyrites (*Min.*) *See* IRON PYRITES.

Pyrites Burners (*Chem.*) Furnaces used for burning iron pyrites (FeS_2) in air with the object of producing sulphur dioxide for use in the manufacture of sulphuric acid. *See* SULPHUR COMPOUNDS.

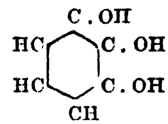
Pyrocatechin (*Chem.*) *See* CATECHOL.

—— (*Photo.*) This substance, sometimes called CATECHOL, is the same in composition as Hydroquinone, having the formulæ $C_6H_4(OH)_2$. It is very soluble in water, and used as a developer produces negatives of excellent quality. It has the advantage of being uninfluenced by temperature and of keeping well in solution.

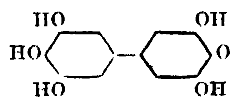
Pyroclastic Rocks (*Geol.*) *See* CLASTIC ROCKS.

Pyroelectricity. Certain minerals, and some other crystalline substances, become electrified on heating or cooling, and are said to be PYROELECTRIC. Among the former are Tourmaline, Calamine, and Boracite (*q.v.*); and among the latter Cane Sugar and Sulphate of Quinine. The phenomena may be illustrated by the case of Tourmaline; while this is being heated, one end becomes positively electrified, the other end negatively; on cooling, the charges are reversed. The results are not only shown by a complete crystal, but also by a broken piece.

Pyrogallic Acid (*Chem.*) A common name for PYROGALLOL (*q.v.*)

Pyrogallol (*Chem.*) 

(PYROGALLIC ACID *or* 1 : 2 : 3-TRIHYDROXYBENZENE). A white solid crystallising in white shining leaves or needles; melts at 132°; soluble in water; less soluble in alcohol and ether; its solution in water gives a blue colour with ferrous sulphate, containing some ferric salt, and a red colour with ferric chloride. Its alkaline solution reduces gold, silver, and mercury solutions to the metal, the pyrogallol being oxidised to acetic and oxalic acids; it also reduces copper sulphate to cuprous oxide. The alkaline solution rapidly absorbs oxygen from the air, turning brown, then black, and being oxidised as above. On these actions of pyrogallol is based its application as a developer in photography and as a solvent for oxygen in gas analysis. If baryta water is used as the alkali, the oxidation does not proceed so far, and it is possible to isolate 3 : 4 : 5 : 3′ : 4′ : 5′-hexahydroxydiphenyl —



When pyrogallol is oxidised by an acid solution of potassium permanganate, or, better still, by electrolysis of a solution in sodium sulphate, using a rotating platinum anode, a dye called purpurogallin is formed —constitution not settled, but probably it is a naphthalene derivative. With bromine, pyrogallol yields tribrompyrogallol. Pyrogallol is obtained by heating gallic acid (*q.v.*), alone or with water, at 210°. It is also formed, usually with other products, when numerous phenol derivatives are fused with caustic potash.

—— (*Photo.*) This substance, sometimes called PYROGALLIC ACID, is a benzene derivative, having the formula $C_6H_3(OH)_3$. It is a colourless crystalline substance, very soluble in water, and in conjunction with an alkali was for a long time the principal developer employed for use with gelatine dry plates.

Pyroligneous Acid (*Chem.*) When wood is submitted to dry distillation in iron retorts a distillate is obtained which separates into two parts just as the liquid distillate from coal does. The aqueous distillate from wood is called pyroligneous acid. It is the chief source of acetone, methyl alcohol, and acetic acid. When this acid liquid is neutralised with milk of lime and distilled, a crude calcium acetate remains behind in solution. The solution is evaporated, and the residue carefully heated to expel volatile organic matter; then the residue is distilled with hydrochloric acid, and gives a crude

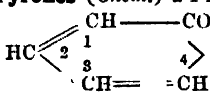
acetic acid of about 50 per cent., which is used for many technical purposes. To obtain glacial acetic acid from the crude acid, it is neutralised with sodium carbonate, evaporated to dryness, fused, and distilled with strong sulphuric acid. The distillate is glacial acetic acid. *See also* METHYL ALCOHOL *and* WOOD SPIRIT.

Pyrolusite (*Min.*) Manganese dioxide, MnO_2. Manganese = 63, oxygen = 37 per cent. Orthorhombic, but usually pseudomorphous after other manganese ores. Colour, iron black. It is of importance in the making of bleaching agents. From Cornwall and many other localities in England; from Thuringia, Moravia, etc.

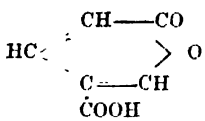
Pyrometer. Any instrument for measuring temperatures above the range of ordinary thermometers. *See* MEASUREMENT OF TEMPERATURE.

Pyromorphite (*Min.*) A phosphate and chloride of lead, $3Pb_3P_2O_8 . PbCl_2$. It contains 60 to 80 per cent. of lead phosphate and 8 to 10 per cent. of lead chloride. Hexagonal; in short prisms in various shades of green, yellow, and brown. It is a valuable ore when occurring in quantity. From the Cornish mines, Caldbeck Fell mines in Cumberland, Leadhills in Scotland, and many places abroad.

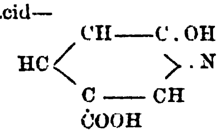
Pyrones (*Chem.*) α-PYRONE—


(*also called* COUMALIN).

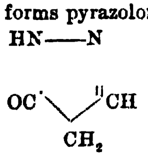
A liquid; melts at 5°; boils with slight decomposition at 206° to 209°, but without decomposition at low pressures; soluble in water; soluble in alkalis forming salts of the acid, $CHO . CH_2 . CH : CH . COOH$; smells like coumarin. It is prepared by distilling the mercurous salt of coumalic acid in a current of steam, and extracting the distillate with ether. *Derivatives:* COUMALIC ACID (α-pyrone-3-carboxylic acid)—



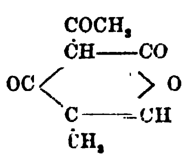
Is obtained by heating malic acid with concentrated sulphuric acid or zinc chloride. Its alkaline salts are yellow. Ammonia converts it (in the cold) to oxynicotinic acid—



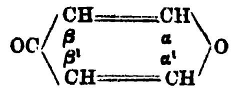
With hydrazine it forms pyrazolone—



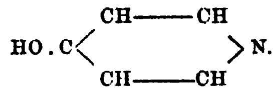
DEHYDRACETIC ACID (1-aceto-3-methyl-αγ-pyrone)—



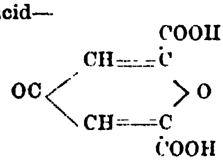
Is obtained when ethyl acetoacetate is heated alone or by the action of pyridine on acetyl chloride. γ-PYRONE—



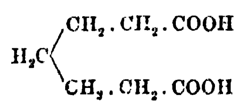
Forms small white crystals, which melt at 32° and boil at 210° to 215°; very soluble in water; reduces Fehling's solution; gives the iodoform reaction. When evaporated with ammonia it gives γ-hydroxypyridine—



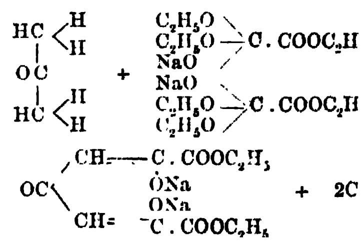
It is obtained by heating chelidonic or comenic acids. Derivatives of γ-pyrone are named by lettering the carbon atoms as shown above, or by numbering all the atoms which form the ring, starting with the oxygen atom as 1. Meconic acid, comenic acid, and pyromeconic acid are γ-pyrone derivatives. *See* MECONIC ACID. Chelidonic acid is γ-pyrone-αα'-dicarboxylic acid—



It crystallises in small needles, which contain one molecule of water, which is lost at 150°; melts at 220°, warmed with alkalis it yields the yellow coloured salts of xanthochelidonic acid (acetone-dioxalic acid); on reduction with hydriodic acid it yields hydrochelidonic acid first, then normal pimelic acid—

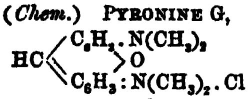


With ammonia it yields γ-oxy-αα'-pyridine dicarboxylic acid. Boiled with milk of lime it gives acetone and calcium oxalate. The acid occurs in celandine along with malic acid. It has been obtained artificially by condensation of ethyl oxalate and acetone by means of sodium ethoxide—



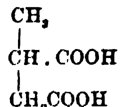
The product on acidifying yields xanthochelidonic ester, which, on heating, loses water and forms the chelidonic ester. *Benzene Derivatives:* Coumarin (*q v.*) is a benzo-α-pyrone. The Flavones (*q.v.*) are derivatives of γ-benzopyrone. The Xanthones (*q.v.*) are dibenzopyrones.

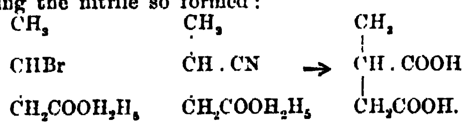
Pyronines (*Chem.*) PYRONINE G,



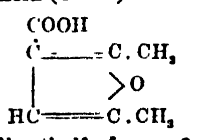
forms shining green crystals soluble in water and alcohol with a red colour showing yellow fluorescence. It is used as a dye for cotton (mordanted with tannic acid), wool, and silk; the shade is bluish red. It is obtained from dimethylmeta-amidophenol (from dimethyl aniline and fuming sulphuric acid, giving the metasulphonic acid, and fusion of the latter with caustic soda) by condensation with formaldehyde, yielding dihydroxytetramethyldiamidodiphenyl methane, which loses water with strong sulphuric acid, forming the leuco compound, and this on oxidation yields the dye. PYRONINE B is the ethyl derivative.

Pyrope (*Min.*) Magnesium aluminium garnet. *See* GARNET. A garnet of deep crimson colour, usually occurring in angular fragments. It is used as a precious stone, and is often cut *en cabochon*. The chief localities are Ceylon and Bohemia.

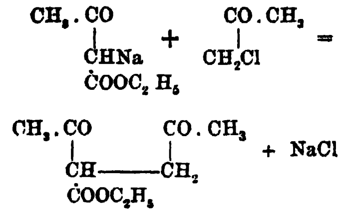
Pyrotartaric Acid (*Chem.*),  (methyl succinic acid). White solid crystallising in groups of small prisms. Melts at 112°; soluble in water, alcohol, and ether. Quickly heated to over 200°, it yields an anhydride; but on keeping it just over 200° it gives butyric acid and carbon dioxide. It contains an asymmetric carbon atom, and can be resolved into its components by strychnine, the dextro form separating first on crystallisation. It is prepared by heating tartaric acid till fumes are evolved, then mixing with its own weight of powdered pumicestone and distilling (nine hours); the distillate is extracted with water, separated from oil, evaporated and crystallised from dilute nitric acid. It can be prepared by heating pyruvic acid; also synthetically from the ethyl ester of β-brombutyric acid by heating with potassium cyanide and hydrolysing the nitrile so formed:



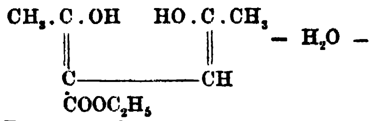
Pyrotritaric Acid (*Chem.*)



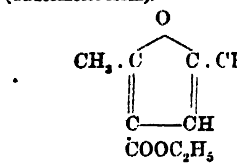
(Uvic acid: $\alpha\alpha'$-dimethylfurfurane-β-carboxylic acid). A white crystalline solid (needles). Melts at 135°; slightly soluble in cold water, more soluble in hot water, very soluble in alcohol and in ether. Heated alone it gives $\alpha\alpha'$-dimethylfurfurane; heated with water at 150 to 160° it forms acetonyl acetone. *See* DIKETONES. It occurs among the products of the dry distillation of tartaric acid; it is also formed when pyruvic acid (*q.v.*) is heated with anhydrous sodium acetate and acetic anhydride at 140°. Synthetically it can be made by the action of monochloracetone (from acetone by the action of chlorine in presence of calcium carbonate) on the sodium compound of ethyl acetoacetate, forming ethyl acetonylacetoacetate, which is then treated with concentrated hydrochloric acid to take away the elements of water:



Ethyl acetonylacetoacetate.



Ethyl acetonylacetoacetate (Tautomeric form).

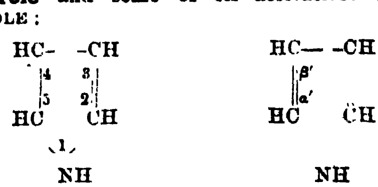


Pyroxene (*Min.*) This term now includes as one species several rock constituents formerly regarded as different. They are normal metasilicates, chiefly of calcium and iron or magnesium, and are monosymmetric. Some varieties contain aluminium, as does one of the best known members of the series, Augite. In colour the Pyroxenes usually range from light to dark green.

Pyroxylin (*Chem.*) A mixture of cellulose nitrates, *viz.* the trinitrate, tetranitrate, and pentanitrate, $C_{12}H_{17}(NO_3)_3O_7$, $C_{12}H_{16}(NO_3)_4O_6$, $C_{12}H_{15}(NO_3)_5O_5$. It is made by immersing pure cellulose (purified cotton wool) in a mixture of sulphuric acid (five volumes sp. gr. 1·84) and nitric acid (four volumes sp. gr. 1·38) for about ten minutes at a temperature of 65° to 70°, then thoroughly washing the product. It is an amorphous white solid, soluble in a mixture of alcohol and ether. This solution is called Collodion (*q.v.*) *See also* CELLULOID.

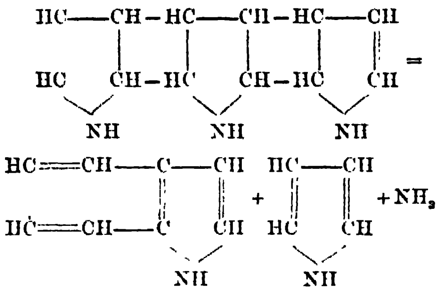
Pyrrhotine (*Min.*) Sulphide of iron, FeS. Iron = 60·5, sulphur = 39·5 per cent. Hexagonal, but usually massive; in brownish masses, with an uneven fracture, metallic lustre and often bronzy tarnish. It is magnetic, and hence is sometimes called Magnetic Pyrites. Sometimes it contains enough nickel to constitute a source of nickel. Widely distributed, but usually in small quantities, and most commonly in connection with metamorphic limestones.

Pyrrole and some of its derivatives (*Chem.*) PYRROLE:

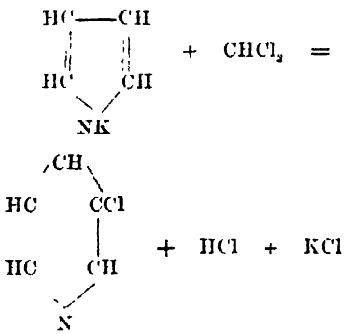


A colourless liquid; boils at 130°; sp. gr. at 12·5°, 0·975. Slightly soluble in water; very soluble in alcohol and in ether; insoluble in dilute alkalis. It

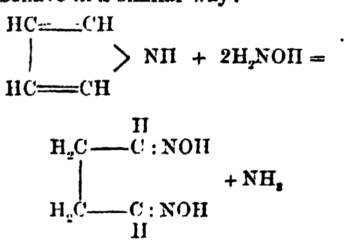
smells like chloroform; turns brown on exposure to air; its vapour turns a pine shaving dipped in hydrochloric acid a red colour—many of its derivatives, *e.g.* those from 1:4-diketones (*q.v.*), hæmopyrrole, indole (*q.v.*), carbazole (*q.v.*), do the same. Pyrrole dissolves in dilute acids, and on warming the solution, or allowing it to stand, an amorphous red substance called pyrrole-red separates; strong acid resinises pyrrole; if the solution in fairly strong hydrochloric acid be neutralised with ammonia, filtered, and the filtrate extracted with ether, a polymer called tripyrrole is obtained—a white crystalline solid which gives indole when heated at 300°:



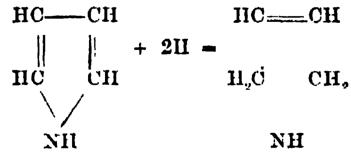
Metallic potassium dissolves in pyrrole with evolution of hydrogen, forming a white crystalline solid, potassium pyrrole, C_4H_4NK; the same substance is obtained by boiling pyrrole with solid caustic potash. Sodium acts far more more slowly. The potassium compound is important, because the potassium is replaced by alkyl groups when warmed with alkyl halogen compounds; also because it yields pyridine when heated with methylene iodide, and β-chlorpyridine when heated with chloroform:



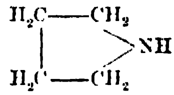
Water decomposes potassium pyrrole into caustic potash and pyrrole. With hydroxylamine pyrrole gives the oxime of succinic aldehyde. Many pyrrole derivates behave in a similar way:



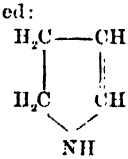
When pyrrole is heated with ammonium carbonate solution at 130° to 140°, it yields pyrrole-a-carboxylic acid. When pyrrole is reduced by zinc dust and hydrochloric acid (the pyrrole is added gradually with shaking, and the strength of the acid is gradually increased), not over 25°, PYRROLINE is formed—a colourless liquid which boils at 90°, fumes in air, and is very hygroscopic:



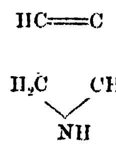
When reduced by hydriodic acid and phosphorus at 240° to 250°, pyrrole yields PYRROLIDINE:



which is a colourless liquid, boiling at 87°, and closely resembling piperidine in its properties; *e.g.* it smells like it, and is a strong base, and it can be obtained by heating the hydrochloride of tetramethylene diamine (putrescine). Pyrrole occurs in coal tar, in bone oil, and in shale oil; it is among the products obtained by the dry distillation of gelatine and of hæmatin. Its chief source is bone oil. The oil is distilled and shaken with dilute acid, to remove strongly basic substances, then fractionated, and the fraction 98° to 150° collected separately; this fraction is boiled with solution of caustic potash under a reflux condenser, to hydrolyse nitriles; it is again fractionated, collecting separately the 115° to 130° fraction; this fraction is heated with solid caustic potash (powder) under reflux condenser; potassium pyrrole is formed: filter, press, dissolve in water, and distil with steam; separate distillate; dry over solid caustic soda; redistil. Pyrrole can be obtained from the ammonium salt of mucic acid (*q.v.*) by distilling it alone, or, better, with addition of glycerine at 200°. It can be obtained from succinimide (*see below*); and by passing acetylene and ammonia through a redhot tube (probable origin of pyrrole in coal tar); by heating its carboxylic acids; and in other ways. For its homologues, *see below*. *Derivatives:* Pyrrole derivatives are named by numbering or lettering the elements which form the ring, as shown above, then indicating the position of the substituting element or group by the proper number or letter, and naming the substituting group. Examples below. The following names are also employed:



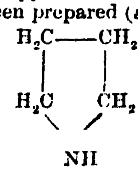
Δ_2-pyrroline.



Δ_3-pyrroline.

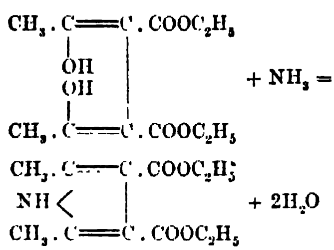
See NOMENCLATURE.

Derivatives of both pyrrolines are known; but only Δ_3-pyrroline has been prepared (*see above*).

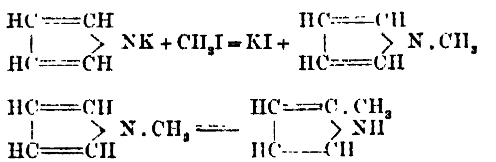


Pyrrolidine.

When in the pyrrolines or in pyrrolidine a CH_2 group becomes a CO group, the new compound is called respectively a pyrrolone or ketopyrroline, a pyrrolidone or ketopyrollidine. Examples below. *Halogen derivatives:* TETRACHLORPYRROLE is an unstable solid; melts with decomposition at 110°. It is obtained by the action of chlorine on an alcoholic solution of pyrrole, or by the action of sodium hypochlorite on pyrrole. Acted on by potassium iodide it yields iodol. TETRIODOPYRROLE (*see* IODOL). *Homologues of Pyrrole:* General reactions for the preparation of these are: (1) Action of ammonia on γ-diketones (*see* DIKETONES), or on their acid derivatives; in the latter case carboxylic acids are formed, and these on heating with quicklime give the hydrocarbons. *Example:* The sodium compound of ethyl acetoacetate when treated with iodine yields diacetyl succinic acid (*see* DIKETONES); this acid is the dicarboxylic acid corresponding to the 1 : 4-diketone acetonyl acetone. With ammonia it yields (working with its ester) 1 : 5-dimethylpyrrole-3 : 4-dicarboxylic acid ethyl ester:

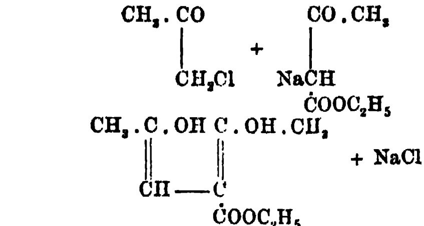


In this synthesis, if a primary amine is used instead of ammonia, the N-alkyl homologues may be obtained. (2) N-alkyl pyrroles may be obtained from potassium pyrrole by the action of alkyl iodides, also by reduction (distillation with zinc dust) of N-alkyl succinimides. These N-alkyl pyrroles on heating are transformed into 1-alkyl pyrroles. Example:

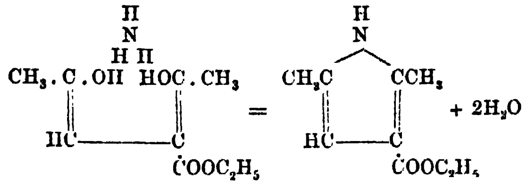


2-methyl pyrrole.

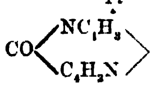
Although not strictly a homologue, β-pyridyl-α-pyrrole may be referred to here. Its preparation is given under NICOTINE (*q.v.*) It consists of white needles, melting at 72°; very soluble in alcohol, ether, and benzene; its solution fluoresces blue. HÆMOPYRROLE (*see* HÆMOGLOBIN) is an oil with characteristic smell; sparingly soluble in water; turns red on exposure to air. The colouring matter produced appears to be identical with UROBILIN. CARBOXYLIC ACIDS: These are obtained by fusing pyrrole homologues with caustic potash; by the action of carbon dioxide upon potassium pyrrole; from pyrrole and its homologues by the action of alcoholic potash and carbon tetrachloride; synthetically in several ways. Example: When monochloracetone acts upon the sodium compound of ethyl acetoacetate and the product is treated with ammonia, the ethyl ester of 1 : 5-dimethylpyrrole-4-carboxylic acid is obtained.



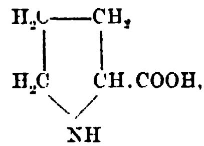
Enol form.



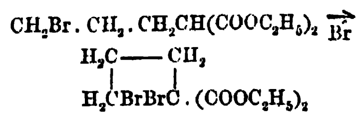
Other γ-ketonic acid esters and other monochlorketones can be used in this synthesis; also the ammonia can be replaced by an amine. A derivative of pyrrole-α-carboxylic acid called *pyrocoll*,



CO, is obtained by the distillation of gelatine. *Pyrroline derivative:* DIHYDRONICOTYRINE (*see* NICOTINE) is a pyrroline derivative. *Pyrrolidine derivatives:* NICOTINE (*q.v.*) is 1-methyl-2-pyridyl pyrrolidine; α-PYRROLIDINE CARBOXYLIC ACID,

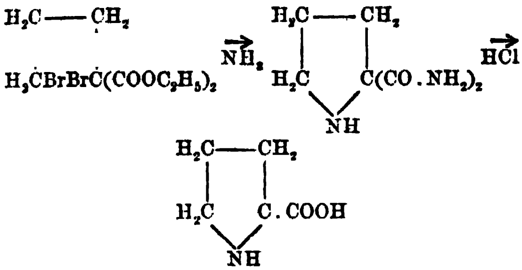


is a decomposition product of proteids. It has been found among the products of proteid hydrolysis by both hydrochloric acid and caustic soda. It was first obtained from casein (3·2 per cent.), and has since been obtained from the most varied proteids. As it contains an asymmetric carbon atom, it can exist in a dextro, lævo, and racemic form. The lævo form has a rotation $[\alpha]_D = -46{\cdot}53°$ in hydrochloric acid solution; α-pyrrolidine carboxylic acid is a white crystalline solid which melts with foaming at 205°. It is soluble in water; has a sweet taste; decolorises alkaline, but not acid permanganate; warmed with silver oxide it gives a mirror. It forms a characteristic copper salt which is sparingly soluble in cold water and easily soluble in warm water. The phenyl cyanate compound is formed in alkaline solution, and melts about 170° with foaming; with difficulty soluble in water. The acid has been synthesised thus: trimethylene bromide (from allyl bromide and hydrogen bromide) and ethyl sodium malonate give ethyl brompropylmalonate, which with bromine forms ethyl α δ-dibrompropylmalonate:

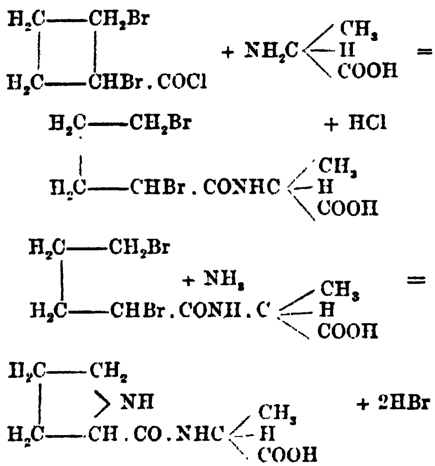


With ammonia the latter yields an amide which is

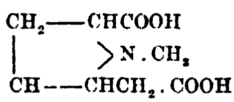
converted by heating with hydrochloric acid into α-pyrrolidine carboxylic acid :



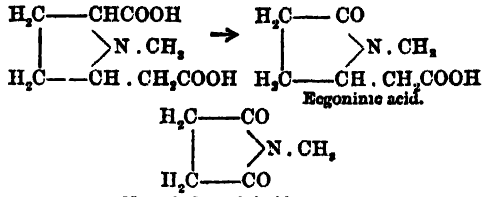
Fischer has proposed the name PROLINE for this acid for shortness. He has combined it with alanine to form a "dipeptide" called PROLYLALANINE by acting on an alkaline solution of alanine with the chloride of α δ-dibromvaleric acid, and treating the product with ammonia:



Prolylalanine is a white crystalline solid, soluble in water, and gives a white precipitate with phosphotungstic acid.

TROPINIC ACID, 

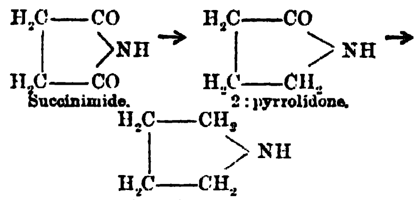
(1-methyl-2-carboxypyrrolidine acetic acid) is a white crystalline solid. As it contains two asymmetric carbon atoms, it should exist in several forms, only three of which are known—namely, an inactive form, a lævo and a dextro form. The inactive form has been resolved by cinchonine. Tropinic acid is obtained by the oxidation of both tropine and ecgonine (*see* ATROPINE *and* COCAINE) by means of chromic acid. The first product of oxidation in each case is tropinone, and this on further oxidation yields tropinic acid. The acid from tropine is inactive, that from ecgonine is dextrorotatory. The lævo acid was obtained by resolution of the inactive acid. The dextro acid melts at 253°, the inactive at 250°, and the lævo at 243°. The inactive acid is very soluble in water, and reduces ammoniacal silver on warming, forming a mirror. On oxidation with concentrated chromic acid tropinic acid yields ecgoninic acid, then N-methyl succinimide :



Ecgoninic acid.

N-methyl succinimide.

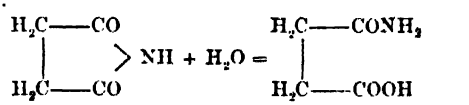
SUCCINIMIDES are 2 : 5-pyrrolidones (or 2 : 5-diketopyrrolidines). Succinimide itself crystallises in colourless plates with one molecule of water of crystallisation ; melts (anhydrous) at 126° ; boils at 228° ; soluble in water, the solution acting as an acid. Distilled with zinc dust it gives pyrrole. When reduced electrolytically, it gives 2-pyrrolidone. Its alcoholic solution, heated with sodium, gives pyrrolidine :



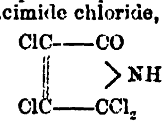
Succinimide. 2 : pyrrolidone.

Pyrrolidine.

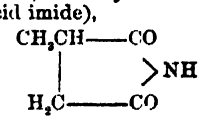
On hydrolysis with an alkali it gives succinamic acid :



With bromine and an alkali it yields β-aminopropionic acid. Phosphorus pentachloride converts it into dichlormaleicimide chloride,



and higher chlorinated pyrroles. Succinimide may be prepared by dissolving succinic acid in 25 per cent. ammonia, evaporating with constant stirring till the temperature rises to 200°, and distilling the product. On re-distillation a pure product is obtained. Homologues of succinimide can be obtained in an analogous way, *e.g.* N-methyl-succinimide by boiling a solution of succinic anhydride with methylamine ; 3-methyl 2 : 5-diketo-pyrrolidine (pyrotartaric acid imide),



by heating its anhydride in a stream of ammonia.

Pyrus (*Botany*). A genus of *Rosaceæ*, including the apple (*P. malus*), pear (*P. communis*), quince (*P. cydonia*), and medlar (*P. germanica*).

Pyruvic Acid (*Chem.*), $CH_3.CO.COOH$ (pyroracemic acid). A colourless liquid. Melts at 3° ; boils at 165° to 170°, with decomposition into carbon dioxide and pyrotartaric acid ; but at a pressure of 12 mm. it distils unchanged at 61°. It smells like

acetic acid; it is soluble in water, alcohol, and ether. On account of the ketone group it shows the reactions of a ketone, *e.g.* it is reduced by zinc and dilute sulphuric acid to lactic acid, $CH_3CHOHCOOH$. Phosphorus pentachloride converts it into α-dichlorpropionic acid; with hydroxylamine it yields an oxime; with sodium hydrogen sulphite it yields an additive compound; with hydrocyanic acid it gives a nitrile; with phenylhydrazine it yields a hydrazone which on being heated with hydrochloric acid gives α-indole carboxylic acid:

$$\begin{array}{l} CH_3 \\ | \\ C:N.NH.C_6H_5 \\ | \\ COOH \end{array} = \begin{array}{l} C \left\langle \begin{array}{l} CH \\ NH \end{array} \right\rangle C_6H_4 + NH_3. \\ | \\ COOH \end{array}$$

Boiled with baryta water it yields pyrotartaric, pyrotritaric, and uvitic acids (*see these*). Pyruvic acid reduces ammoniacal silver nitrate, being oxidised to carbon dioxide and acetic acid. Heated with dilute sulphuric acid at 150°, it gives carbon dioxide and aldehyde. The acid is prepared by distilling previously fused tartaric acid and fractionating the product, or by distilling a mixture of tartaric acid and acid potassium sulphate. Synthetically it is formed by hydrolysing acetyl cyanide, CH_3COCN (from acetyl chloride and silver cyanide), with hydrochloric acid.

Q, *q*. A symbol often used for Quantity, especially a Quantity of Electricity.

Quadrangle (*Architect.*) A square or rectangular court surrounded by buildings.

Quadrant. (1) The part of a circle bounded by two radii at right angles to each other, and by the arc of the circumference lying between them; one-fourth of the area of a circle. (2) An instrument resembling the Sextant (*q.v.*)

Quadrant Electrometer (*Elect.*) *See* ELECTROMETER.

Quadrant Plate (*Eng.*) A plate hinged at the end of the bed of a screw cutting lathe, the axis on which it turns being the end of the leading screw. It carries the change wheels used in screw cutting.

Quadrats (*Typog.*) Metal spaces or blocks of rectangular shape, used for spacing, and especially for filling up short lines. Quadrats stand lower than the face of the adjoining type, and are of various sizes. *See under* TYPE.

Quadrature (*Astron.*) Two heavenly bodies are said to be in quadrature when there is a difference of longitude of 90° between them.

Quadripartite Vaulting (*Architect.*) A form of vaulting in which the vault over each rectangle is divided into four parts. It is formed by the intersection of two barrel vaults, and is also known as a four part vault. *See* GROINED VAULT *and* SEXPARTITE VAULT.

Quadruple Expansion (*Eng.*) The expansion of steam in four successive cylinders of an engine. It is doubtful if this method has any great advantage over TRIPLE EXPANSION (*q.v.*)

Quadruplet (*Cycles*). A form of bicycle propelled by four riders, seated one behind the other.

Quadruplex Telegraphy (*Elect.*) The simultaneous use of a telegraph circuit for four messages, two in each direction.

Quaigh (*Archæol.*) A shallow wooden or metal drinking vessel generally with two handles, at one time common in Scotland.

Quaker Blue (*Dec.*) A dull blue made by adding black to Prussian blue and lightening up by means of a little white.

Quaker Drab (*Dec.*) A greenish grey shade obtained by mixing five parts of white with two parts each of medium chrome yellow and chrome green.

Quaker Greens (*Dec.*) A series of somewhat sombre, greyish greens, having no definite composition or shade. The term is variously applied for trade purposes, generally in contradistinction to the bright greens such as Brunswick, chrome, emerald, etc. The following mixture gives a typical Quaker green, one part each of medium chrome yellow, Venetian red and blue black, and three parts of chrome yellow.

Qualitative Analysis (*Chem.*) The method of proceeding in order to ascertain the nature of an unknown element or compound, or of a mixture of these. (a) *Inorganic:* If the substance is a solution, a part is evaporated. The solid is heated to see if it changes colour (*e.g.* zinc compounds are yellow while hot), if it sublimes (arsenic, mercury, ammonia compounds), if it gives off a gas (many nitrates give off nitrogen peroxide, etc.) The solid is then heated on platinum wire, moistening with hydrochloric acid to form if possible a trace of chloride, the chloride being the most volatile salt of a metal; characteristic colours are imparted to the flame by sodium, potassium, and some other metals. A borax bead is made on the platinum wire, a little of the solid added, and the bead fused in the outer flame; cobalt gives a blue bead, manganese an amethyst coloured bead, and so on. A portion of the solid may be mixed with sodium carbonate and potassium cyanide, as this mixture when heated in the blowpipe flame on a piece of charcoal reduces compounds of the easily reducible metals to the metallic state, *e.g.* tin, lead, bismuth, etc.; then the metal itself can be examined. The action of acid is tried, *e.g.* both dilute and concentrated sulphuric acid, first in the cold, then on warming. Many salts, oxides, and metals give off gases which can be readily recognised, *e.g.* a chloride gives off hydrogen chloride, a carbonate carbon dioxide, and so on. If the original substance is a solid, it must now be dissolved, in water if possible; otherwise suitable acids are tried. If the substance will not dissolve, the chemist knows that it can only contain a few substances, such as silica, alumina, barium sulphate, etc.; he then proceeds to make it into a soluble compound by fusion with sodium carbonate or acid potassium sulphate at his discretion. The examination of the solution is in outline as follows: add hydrochloric acid: silver, lead, mercurous compounds are thrown out as chlorides; any precipitate is filtered off. To the clear liquid sulphuretted hydrogen is added; it precipitates the sulphides of those metals which form sulphides insoluble in dilute hydrochloric acid, *viz.* lead, divalent mercury, bismuth, copper, cadmium, tin, arsenic, antimony. Most of these sulphides have characteristic colours; any precipitate is filtered off. To the clear liquid ammonium chloride and ammonia are added, and more sulphuretted hydrogen; this mixture gives us sulphides of metals which are soluble in dilute acid but not soluble in ammonia, also the hydroxides of aluminium and chromium and certain phosphates; any precipitate is filtered off. To the clear liquid

ammonium carbonate is added, calcium barium and strontium are precipitated as carbonates; any precipitate is filtered off. To a part of the clear liquid sodium phosphate is added; this gives us magnesium as ammonium magnesium phosphate. The rest of the clear liquid is evaporated to dryness and strongly heated, when only sodium and potassium compounds remain. The reagents added above are called *Group Reagents*, and they must be added as long as they produce a precipitate. All the precipitates are then examined separately by suitable methods to ascertain what metals of the group are present. When this has been done the analyst knows what metals are present, and this gives him valuable information as to the acids that may be united with them. The procedure for ascertaining the acids is less systematic: the action of sulphuric acid before mentioned gives valuable information; the solution, properly prepared and treated with barium nitrate and silver nitrate respectively, gives further information, and the analyst's knowledge and discretion decide the remaining operations. (b) *Organic:* The component elements must be ascertained; carbon and hydrogen, by heating with copper oxide, which oxidises any organic compound to carbon dioxide and water; nitrogen, by heating with sodium, which forms sodium cyanide with any organic substance containing nitrogen; if a cyanide is formed it can be detected by converting it into Prussian Blue (*q.v.*); sulphur, phosphorus, and halogens, by heating with nitric acid in a sealed tube, when these elements are converted respectively into sulphuric, phosphoric, hydrochloric, etc., acids, and these can be easily detected. The melting and boiling point should be taken next; if these are constant the substance is probably a pure compound, if not it is a mixture. The substance must now be examined as to its class by making use of reactions suitable to the detection of a hydrocarbon, alcohol, aldehyde, ketone, acid, amine, amide, etc. This being done, the melting point or boiling point will usually settle what particular alcohol, etc., it is. If the substance is a mixture, there is no method applicable to every case, and the analyst must be guided by his knowledge of the source of the substance and by any information he can glean from its chemical behaviour. Thus, if an analyst were given a piece of pitch to analyse he would not return a list of compounds he had extracted from the pitch—that would mean a long research; he would return the constituent elements, and perhaps state what fraction of the pitch was soluble in a particular solvent. In any analysis a substance which has no striking reaction, and is present in small quantity, may easily be missed; thus air had been analysed thousands of times, both qualitatively and quantitatively, before Rayleigh and Ramsay discovered argon in it, although this element forms nearly 1 per cent. of air.

Quandel. The central stake round which wood is arranged in forming a MEILER, *i.e.* the basin shaped stack in which the wood is piled by charcoal burners.

Quantitative Analysis (*Chem.*) The determination of the proportion by weight of any substance or substances contained in the material to be analysed. Before a quantitative analysis can be made a careful qualitative analysis must have been made. Then only can a method for a quantitative analysis be chosen. The analysis may be Gravimetric or Volumetric. In a Gravimetric analysis the substance to be estimated is converted into an insoluble compound of known composition, which can be filtered off, washed till free from excess of the precipitant, dried and weighed. Thus, to estimate the copper in a solution of copper sulphate, a weighed amount of the latter is taken, dissolved in water, a slight excess of caustic soda added to the hot solution so as to form hydrated copper oxide, which is filtered off, washed, dried, and ignited so as to form copper oxide, which can be weighed: the composition of copper oxide being known, it is clear that we should then know the proportion of copper in the original sulphate. For the method of Volumetric analysis *see* VOLUMETRIC ANALYSIS.

Quaquaversal (*Geol.*) An unusual type of inclination of strata in which the rocks dip outwards in all directions from some particular point, so that they form a series of domes or inverted basins over one another. The correlative term CENTROCLINAL DIP is employed in describing the opposite arrangement, in which the strata are inclined inwards towards a central point. This latter arrangement often occurs in volcanic necks.

Quarrel (*Architect.*) (1) A small, square, or diamond shaped piece of glass. (2) A similarly shaped brick, tile, or stone used in paving.

Quarrell (*Arms*). A short, thick, square headed arrow or bolt used with the crossbow. *See also* BOLT.

Quarry. An open pit or excavation from which stone and other materials are dug.

—— (*Architect.*) *See* QUARREL.

Quart. *See* WEIGHTS AND MEASURES.

Quarter. *See* WEIGHTS AND MEASURES.

—— (*Her.*) The canton (*q.v.*) now takes the place of the quarter

Quartered (*Her.*) Divided. *Quarterly:* Divided into four quarters or into more than four sections. A field may be quarterly of six or of eight, etc.

Quartering (*Carp.*) A term generally applied to strips of timber produced by cutting deals (*q.v.*) into four.

Quarterings (*Her.*) Several coats of arms blazoned on one shield either in four equal quarters or in a greater number of sections, according to the number of coats it is necessary to include. The sections are always equal in number, the principal coat being repeated if necessary.

Quarternary (*Geol.*) The geological formations of later date than that of the Pliocene Period.

Quaternary Ammonium Compounds (*Chem.*) Compounds of the type

$$\left.\begin{array}{l} R_1 \\ R_2 \\ R_3 \\ R_4 \end{array}\right\rangle N.X.$$

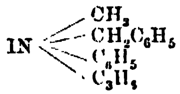
where R_1, R_2, R_3, R_4, are radicals joined to the nitrogen atom by carbon, and X is a hydroxyl group or a halogen. *E.g.* benzylphenylallylmethylammonium iodide,

$$I.N\left\langle\begin{array}{l} CH_2C_6H_5 \\ C_6H_5 \\ C_3H_5 \\ CH_3 \end{array}\right.$$

The quarternary ammonium hydroxides are powerful bases acting like caustic soda or potash; they absorb carbon dioxide from the air and neutralise the strongest acids, forming well crystallised salts. They

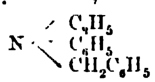
are obtained from amines by the action of alkyl iodides or bromides; this gives the quaternary ammonium iodide or bromide which can be decomposed by moist silver oxide. *E.g.* the above compound can be obtained: (*a*) from methyl aniline by the action of benzyl chloride upon it, yielding methylbenzylaniline,

and then acting on this compound with allyl iodide, yielding

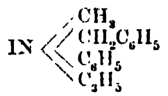


(*b*) from aniline by the action of allyl iodide (in the cold), forming

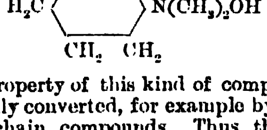
acting on the allyl aniline with benzyl chloride forming benzylallyl aniline,



and acting on the latter with methyl iodide, yielding



Although the iodides so prepared have the same chemical composition, they differ widely in physical properties; *e.g.* in melting point (dissociation point), specific gravity, crystalline form—they are isomeric. The chloroplatinate of methyldiethylisobutylammonium exists in two isomeric forms. Various explanations of this kind of isomerism have been advanced, but none is completely satisfactory. The isomerism does not occur with simple radicals; thus trimethylisobutylammonium salts show isomerism, but trimethylpropylammonium salts and dimethyldiethylammonium salts do not show isomerism. When the four organic radicals attached to the nitrogen atom are all different, the compound can be resolved into dextro-rotatory and lævo-rotatory forms: thus *a*-benzylphenylallylmethylammonium hydroxide (the compound prepared by method *a* given above) can be resolved by means of *d*-camphorsulphonic acid into its optically active components, the dextro rotatory ammonium compound of the sulphonic acid being less soluble than the lævo-rotatory compound. As quaternary ammonium compounds are considered those compounds where two of the four radicals R_1, R_2, R_3, R_4, are replaced by a ring; *e.g.*



A general property of this kind of compound is that they are easily converted, for example by distillation, into open chain compounds. Thus the dimethylpiperidinium hydroxide of the above formula gives Δ_4-pentenedimethylamine,

$$CH_2 : CH . CH_2 . CH_2 . CH_2 . N(CH_3)_2$$

Quarter Partition (*Build.*) A lath and plaster partition.

Quarter Plate (*Photo.*) A plate measuring $4\frac{1}{4}$ in. by $3\frac{1}{4}$ in.

Quarter Pyramid (*Min.*) One of the four pairs of faces making up a pyramid form of the Triclinic System.

Quarter Rip Saw (*Carp.*) Another name for a HAND SAW. *See* SAWS.

Quarters of the Moon (*Astron.*) When only one half of the illuminated portion of the lunar surface is visible. There are first and last quarters.

Quarter Space Landing (*Build.*) A landing whose width is equal to that of the ***stairs*** only, as distinguished from a HALF SPACE LANDING which extends the full width of the ***staircase***.

Quartet, Quartett (*Music*). A composition for four voices or instruments. A string quartet is a musical composition for four stringed instruments, generally two violins (first and second), viola, and violoncello. The family of "strings," *viz.* violin, viola, violoncello, and double bass, is sometimes spoken of as the quartet of strings.

Quarto. In printing, etc., a sheet which when folded makes four leaves. In the smaller sizes the height and breadth are nearly the same. Abbreviation, 4to.

Quartz (*Geol.*) A rock constituent of considerable importance. It occurs (1) as a primary mineral of the acid eruptive rocks, (2) as a mineral of secondary origin due to the decomposition of silicates, (3) in the form of veins, (4) as a derivative mineral, *e.g.* in the form of quartz pebbles or quartz sand. Quartz is characteristic of rocks of terrigenous origin, *i.e.* it is absent from oceanic deposits.

—— (*Min.*) Silicon dioxide, SiO_2. Silicon = 46·67, oxygen = 53·33. Rhombohedral. Transparent to opaque. Pure Quartz is colourless, but it is frequently coloured by various impurities, appearing brown, red, yellow, green, violet, etc. It is a mineral of the widest distribution, occurring both as a rock constituent and in veins. Quartz veins or "reefs" are often of great size, and are the commonest carriers of gold in gold bearing districts. Quartz is frequently found in gangue metal in metalliferous veins. Pure Quartz of the variety Rock Crystal is used for the manufacture of spectacle lenses under the name "pebble," and more recently for light treatment in Medicine. Pure Quartz sand is used in the manufacture of the soluble silicates of sodium and potassium known as "water glass," and also for many other industrial purposes. The chief varieties of Quartz are Rock Crystal, Amethyst, Smoky Quartz or Cairngorm, Aventurine, Cat's Eye, and Ferruginous Quartz. Chalcedony, which is often classed with Quartz, is really a mixture of anhydrous and hydrous silica.

Quartz Fibres (*Phys.*) Fine fibres produced by rapidly drawing out a piece of quartz when fused in the oxyhydrogen flame. These fibres can be made thinner than any natural fibre (*e.g.* unspun silk), and on account of their strength and elasticity are used in very sensitive galvanometers, electrometers, and other instruments containing moving parts which require delicate suspension.

Quartzine (*Min.*) *See* CHALCEDONY.

Quartzite (*Geol.*) A very hard rock, originally consisting of clean quartz sand, which, as a result of later causes, has been compacted by the deposition of secondary quartz between, or on, the grains of sand. The depositing agent has been water containing the silica in solution, in most cases at a moderately high temperature, and charged with an alkali. Impure quartz sand, under the operation of the same causes, passes into greywacké (*q.v.*)

Quartzose. Consisting of or containing a large percentage of quartz. Thus there are quartzose gneisses, quartzose schists and quartzose rocks of derivative origin.

Quartz Porphyry (*Geol.*) An eruptive rock of acid composition, in which blebs of quartz occur in a stony or lithoidal ground mass. Potash felspar is usually present.

Quartz Trachyte (*Geol.*) A synonym of LIPARITE (*q.v.*)

Quasi (*Music*). As if; somewhat; in the style of; as *quasi allegro*, somewhat cheerfully; *quasi sonata*, in the style of a sonata, *i.e.* in irregular sonata form.

Quassia (*Botany*). The wood of the West Indian trees *Picrasma excelsa*, *Quassia amara* (order, *Simarubaceæ*), furnish the Quassia wood. It is used as a bitter tonic.

Quatrefoil (*Architect.*) A cusped opening in Gothic tracery, formed with four foils or spaces between cusps. *See* CUSP, FOIL, TREFOIL, CINQUEFOIL, *and* MULTIFOIL.

—— (*Her.*) A plant with four leaves joined at a common centre, but without stalk. A figure formed of four leaves joined together at a common centre.

Quattro Cento (*Art*). Literally 400, but used as an abbreviation of 1400 (*Cf* CINQUECENTO). A term applied to Italian art, architecture, literature, etc., of the fifteenth century.

Quaver (*Music*). The name of one of the notes and rests. *See* NOTES—RESTS.

Quebracho Bark (*Botany*). The bark of several American trees, *e.g. Aspidosperma Quebracho* (order, *Apocynaceæ*), is imported from Argentina; it contains a number of alkaloids, amongst them ASPIDOSPERMINE, and is used medicinally and in leather tanning.

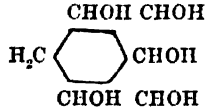
Queen Post (*Build.*) One of the vertical members of a queen post truss. *See* ROOFS.

Queens (*Build.*) (1) Roofing slates measuring 36 in. by 24 in. (2) QUEEN POSTS (*q.v.*)

Quenching (*Eng.*) The sudden cooling of steel by plunging it into water when redhot, whereby it becomes extremely hard.

Quercetin (*Chem.*) *See* FLAVONE.

Quercite (*Chem.*)



(Pentaoxyhexamethylene). Forms colourless prisms; melts at 234°; shows strong triboluminescence; sweet taste; soluble in water; less soluble in alcohol; insoluble in ether. It contains four asymmetric carbon atoms and should exist in twelve active and four inactive modifications. It is only known in one form, which is dextro-rotatory. On heating over 260° quinone, hydroquinone, pyrogallol, and other bodies sublime. It does not reduce Fehling's solution. On oxidation with manganese dioxide and sulphuric acid it gives quinone: with nitric acid it gives trioxyglutaric acid and mucic acid as well as oxalic acid. On reduction with hydriodic acid it gives benzene, phenol, pyrogallol, quinone, hexane, and hexylene. With nitric and sulphuric acids it yields a pentanitrate. It does not ferment with yeast. Quercite occurs in acorns, and is prepared from them. The acorns are extracted with cold water, the solution concentrated at 40° under reduced pressure, fermented with yeast to remove sugar, and treated with basic lead acetate; excess of lead is removed from the filtrate by sulphuretted hydrogen, and the solution is now crystallised: it is purified by recrystallisation from alcohol.

Quercitrin (*Chem.*) A glucoside. It is a yellow crystalline solid, slightly soluble in water; soluble in alkalis and in acetic acid. On boiling with dilute acids it is hydrolysed to rhamnose and quercetin. *See also* FLAVONE.

Quercitron Bark (*Botany*). A North American oak, *Quercus tinctoria* (order, *Cupuliferæ*), whose bark is used as a yellow dye. *See* DYES AND DYEING.

Quern (*Archæol.*) A primitive form of handmill consisting of two circular stones, the upper one fitted with a handle; used for grinding corn and other substances.

Queue (*Her.*) The tail of an animal.

Quick Curve. A curve of small radius.

Quick Gear, etc. (*Eng.*) Any gearing which produces a more rapid motion than the normal or working motion is often described as "quick."

Quicklime. Lime before being slaked; *i.e.* calcium oxide, CaO, as distinguished from the same oxide when combined with water, $Ca(OH)_2$, known as SLAKED LIME. *See* CALCIUM *and* CALCIUM COMPOUNDS.

Quick Return (*Eng.*) Some form of mechanism in machine tools for causing the return stroke (during which the cutting tool is not acting) to be performed more rapidly than the forward or cutting stroke.

Quicksilver (*Min.*) *See* MERCURY.

Quick Vinegar Process (*Chem.*) The process for making vinegar from malt liquor described under acetic acid (*q.v.*)

Quietamente, Quieto (*Music*). Quietly.

Quill (*Silk Manufac.*) *See* PIRN.

Quillaia. *See* QUILLAJA.

Quillaja *or* **Quillaia** (*Botany*). A South American genus of Rosaceæ. *Q. Saponaria* yields the soap bark of Chili, used in pharmacy.

Quinaldine (*Chem.*) Another name for *a*-METHYLQUINOLINE. *See* QUINOLINE.

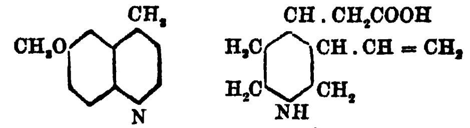
Quincunx. An arrangement of five objects so that four of them occupy the corners of a rectangle, the fifth being placed in the centre. A group of trees so arranged.

Quinic Acid (*Chem.*) $C_6H_7(OH)_4COOH$ (Hexahydrotetrahydroxybenzoic acid). A white crystalline solid; melts at 162°; very soluble in water, less soluble in alcohol, nearly insoluble in ether; lævo-

rotatory. When boiled with water and lead dioxide it gives hydroquinone: distilled with manganese dioxide and dilute sulphuric acid it gives quinone. It is reduced to benzoic acid by hydriodic acid. It is the acid or one of the acids with which the alkaloids are united in cinchona bark. To obtain it the bark is extracted with dilute sulphuric acid, precipitated by milk of lime, filtered, and the filtrate evaporated. The residue is extracted with alcohol—calcium quinate remains: it is purified by recrystallisation from water and decomposed by oxalic acid.

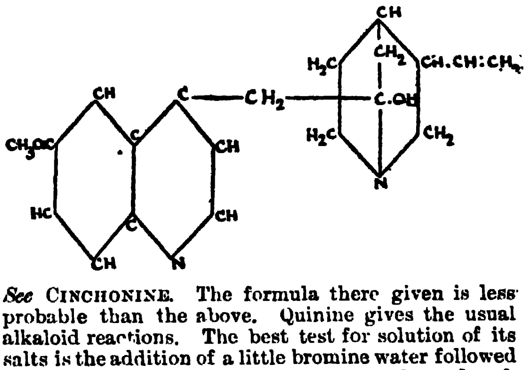
Quinine (*Botany*). This important alkaloid and its salts are obtained from the bark (Peruvian bark) of various species of *Cinchona* (order, *Rubiaceæ*). *See* CINCHONA.

—— (*Chem.*) $C_{20}H_{24}N_2O_2$. Forms white silky needles; where quinine is precipitated from solutions of its salts by ammonia and allowed to stand, the crystals contain three molecules of water; the anhydrous quinine melts at 175°, the hydrated quinine at 57°; it is sparingly soluble in cold water (1 part anhydrous quinine in 1,960 parts of water at 15°); much more soluble in alcohol, ether, chloroform, and hot benzene. Quinine is lævo-rotatory. It occurs in Cinchona Bark and in Remijia Bark. To obtain quinine the cinchona bark is boiled with dilute sulphuric acid, the solution is precipitated with caustic soda solution, the precipitate is dissolved in rectified spirit, neutralised with sulphuric acid, and the alcohol distilled off; crude quinine sulphate crystallises out, it is purified by recrystallisation, being less soluble than the other alkaloid sulphates. From the sulphate, quinine is separated by ammonia or caustic soda. *Salts:* Quinine is a diacid base, and so forms two series of salts—namely, basic salts, which have a neutral reaction, and normal salts, which have an acid reaction. In the following formulæ B stands for one molecule of quinine. The neutral sulphate $B_2H_2SO_4 8H_2O$, commonly called quinine sulphate, is the most important salt; it is a light, silky looking crystalline solid, sparingly soluble in water (1 part in 800 parts water), but readily soluble in water containing a little sulphuric acid when it forms the acid sulphate; the solution shows a blue fluorescence. When the neutral sulphate is dissolved in water containing one molecular proportion of sulphuric acid, alcohol added, brought to boiling, and treated with hydriodic acid and iodine (2HI + 4I), there is deposited on slow cooling a lustrous green crystalline (leaves) solid of the formula $B_4(H_2SO_4)_3(HI)_2I_4 6, H_2O$, called Herapathite. This substance has the remarkable property of polarising light about four times as strongly as tourmaline. The chlorides have the formulæ $B . HCl 2H_2O$ and $B2HCl$.; they are more soluble than quinine sulphate. Many other salts are known, but those mentioned are the ones used in medicine. Thus tincture of quinine contains the hydrochloride, ammoniated tincture of quinine contains the sulphate, ammonia, and alcohol. Quinine solutions have a very bitter taste; they are used in medicine as stomachics and as a preventive and cure for malaria; they are also good antiseptics. *Constitution:* Quinine is methoxycinchonine. *See* CINCHONINE. It is a ditertiary base because it adds on two molecules of methyl iodide; it is an alcohol, as it unites with acid chlorides and anhydrides to form esters; it is unsaturated, as it adds on two atoms of bromine or a molecule of hydriodic acid. When quinine hydrochloride is treated with phosphorus pentachloride it yields a quinine chloride—a hydroxy group is replaced by chlorine. This chloride on boiling with alcoholic potash loses hydrogen chloride and forms quinine. Quinine when heated with phosphoric acid yields paramethoxylepidine and meroquinine:



Paramethoxylepidine. Meroquinine.

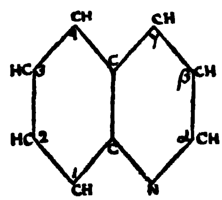
When quinine is oxidised with chromic acid, meroquinine is among the products; another product is quininic acid, which is the carboxylic acid corresponding to paramethoxylepidine (CH_3 changed to COOH). The constitution of meroquinine is fairly well established. On these grounds the formula for quinine is probably



See CINCHONINE. The formula there given is less probable than the above. Quinine gives the usual alkaloid reactions. The best test for solution of its salts is the addition of a little bromine water followed by ammonia, when a bright green colour is produced. The blue fluorescence of the sulphate is very characteristic.

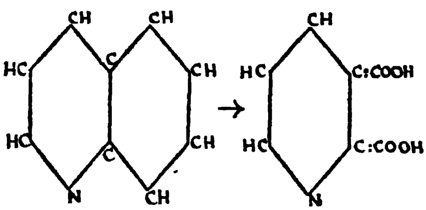
Quinol (*Chem.*) Another name for HYDROQUINONE (*q.v.*)

Quinoline (*Chem.*)



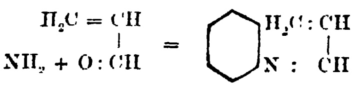
A colourless liquid; boils at 239°; it has a characteristic smell; nearly insoluble in water, readily soluble in the ordinary organic solvents; it is a strong antiseptic. It occurs in bone oil and in coal tar, and is formed when certain alkaloids, *e.g.* cinchonine, quinine, strychnine, are distilled with caustic potash. It is prepared by heating together aniline (38 grms.), glycerine (120 grms.), concentrated sulphuric acid (100 grms.), and nitrobenzene (24 grms.) The heating is done in a flask with reflux condenser; at first the temperature is kept for several hours at about 125°, then raised from 180° to 200°, till all reaction is over Water is added and the product boiled to drive off excess of nitrobenzene. Caustic soda is now added till strongly alkaline, and the mixture is distilled in steam. Aniline is present, and is removed by acidifying the distillate with sulphuric acid and adding sodium nitrite to convert the aniline to diazo-sulphate, which

is converted to phenol on boiling. The liquid is now made alkaline and again distilled in steam, the distillate is extracted with ether, dried over caustic potash, the ether distilled off, then the quinoline is distilled over. This method of preparing quinoline is known as Skraup's synthesis, and the reaction is a general one. *See below.* Quinoline forms salts with acids, *e.g.* $C_9H_7N.HCl$. This hydrochloride forms a double salt with platinic chloride; of the other salts the dichromate, which is very sparingly soluble in water, is important, $(C_9H_7N)_2H_2Cr_2O_7$. It also combines with many salts, *e.g.* with mercuric chloride. As a tertiary base it unites directly with alkyl iodides, forming quaternary ammonium iodides, *e.g.* with methyl iodide it forms methylquinolinium iodide, $CH_3C_9H_7NCH_3I$. On reduction with zinc and hydrochloric acid it forms tetrahydroquinoline—the pyridine ring being reduced; and when the tetrahydroquinoline is reduced with hydriodic acid and phosphorus the benzene ring is reduced, forming decahydroquinoline, $C_9H_{18}N$. When oxidised by potassium permanganate in alkaline solution or in strong sulphuric acid solution the benzene ring is destroyed and $\alpha\beta$-pyridinedicarboxylic acid is formed.

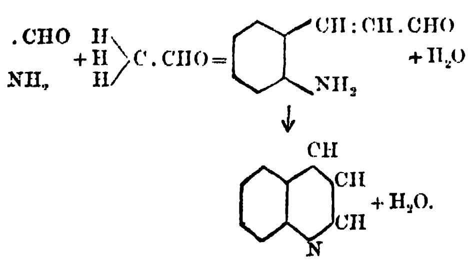


Quinolinic acid.

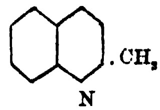
That quinoline has the formula assigned to it is shown by Skraup's synthesis; in this the glycerine is converted into acrolein by the sulphuric acid, and the acrolein condenses with the aniline:



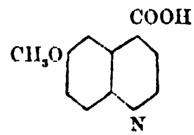
The nitrobenzene acts as an oxidising agent, furnishing oxygen, which unites with an atom of hydrogen adjacent to the nitrogen in the benzene ring and an atom of hydrogen from the methylene group, and thus brings about the ring formation. Another synthesis showing the constitution consists in condensing orthoamidobenzaldehyde with aldehyde in presence of caustic soda, forming orthoamidocinnamic aldehyde, which readily loses water and forms quinoline.



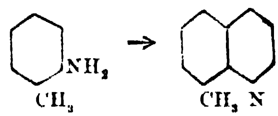
Quinoline derivatives are named by lettering the pyridine ring and numbering the benzene ring as shown in the formula for quinoline; then denoting the position of the substituent by its letter or number, naming the substituent and adding the name quinoline. Position 1 is sometimes called the ortho-position, 2 the meta-position, 3 the para-position, and 4 the ana-position with respect to the nitrogen atom. A number of quinoline derivatives have special names. Examples:



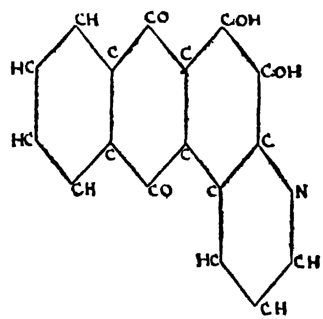
is α-METHYLQUINOLINE—also called QUINALDINE. γ-METHYLQUINOLINE is called LEPIDINE (*q.v.*)



is PARAMETHOXYQUINOLINE-γ-CARBOXYLIC ACID; also called QUININIC ACID. *See* QUININE. Quinoline derivatives can be synthesised (1) by Skraup's synthesis, using in place of aniline any substituted aniline, naphthylamine or substituted naphthylamine, etc., provided an ortho-position to the amido group is vacant. *E.g.* orthotoluidine would give orthomethylquinoline.

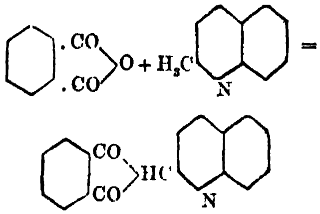


Skraup's synthesis is employed technically in the preparation of alizarine-blue—in fact, it was this preparation which led to its application to the synthesis of quinoline. Alizarine blue,

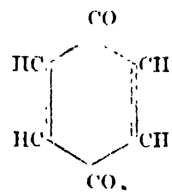


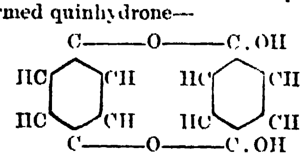
dihydroxyanthraquinonequinoline, is made by heating β-nitroalizarine with glycerine and sulphuric acid: it forms lustrous brownish violet needles, insoluble in water, slightly soluble in alcohol, and is a weak base; it is used chiefly in the form of its sodium bisulphite compound as a blue dye. (2) By heating together aniline, aldehyde, and concentrated sulphuric or hydrochloric acids. This synthesis is general, and various anilines, aldehydes, or an aldehyde and a ketone can be used; *e.g.* aniline and ordinary aldehyde give quinaldine. Quinaldine when heated with phthalic anhydride and zinc chloride

gives quinoline yellow, which is used in colouring wax and varnish.

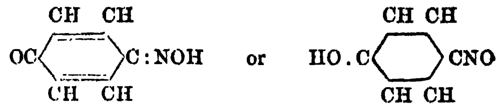


Other quinoline dyes are: Cyanine, a blue dye of unknown constitution obtained from molecular proportions of quinoline and lepidine by the action of amyl iodide and subsequent treatment of the product with caustic soda—used in photography. Quinoline red, obtained by the action of benzotrichloride, $C_6H_5CCl_3$, on a mixture of quinaldine and isoquinoline in presence of zinc chloride, is also used in photography.

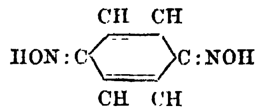
Quinone (*Chem.*)  (Parabenzoquinone). Yellow prisms; melts at 116°; readily sublimes; sparingly soluble in cold water; readily soluble in hot water, in alcohol, and in ether. It has a characteristic penetrating smell. Volatile in steam. Quinone is made by the oxidation of aniline; the aniline is dissolved in dilute sulphuric acid, cooled to 0°, and a strong solution of sodium dichromate added gradually and with constant stirring, keeping the temperature below 10°. After twelve hours a further addition of sodium dichromate (twice as much as before) is made, and the mixture again allowed to stand several hours. The quinone is now extracted with successive large quantities of ether, shaking gently to avoid the formation of a troublesome emulsion. The ether is distilled off, and the quinone distilled over in steam. Another method is to oxidise para-amidophenol sulphate in aqueous solution with lead dioxide and sulphuric acid; extract with ether, and so on as before. Many other paradisubstituted benzene derivatives yield quinone on oxidation. Quinone is an exceedingly active compound chemically; some of its reactions are as follows: It is easily reduced to hydroquinone, *e.g.* acidified potassium iodide reduces it with liberation of iodine; sulphurous acid reduces it. As an intermediate product of its reduction to hydroquinone, there is formed quinhydrone—



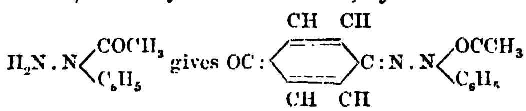
a lustrous green crystalline solid, which is also formed by direct union of quinone and hydroquinone. Chlorine converts quinone into a mixture of trichlor and tetrachlorquinone (chloranil). Its behaviour towards those reagents which act on ketones (*q.v.*) is as follows: (*a*) With hydrocyanic acid it forms 2 : 3-dicyanhydroquinone. (*b*) With hydroxylamine it yields both a monoxime and a dioxime; the monoxime is identical with nitrosophenol (*see* NITROSO COMPOUNDS), so that its formula is—



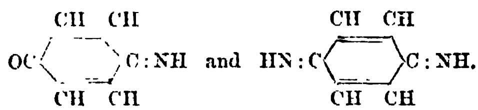
The dioxime has the formula



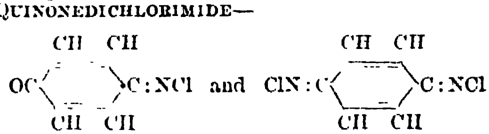
(*c*) With phenylhydrazine it does not give a hydrazone, but is reduced to hydroquinone; if the phenylhydrazine has a hydrogen atom replaced by an acid radical, then a hydrazone is formed, *e.g.*



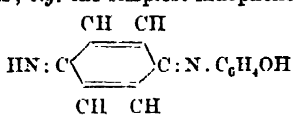
(*d*) With phosphorus pentachloride it gives paradichlorbenzene. Quinone has many important derivatives. Among them may be mentioned: (1) MONIMINOQUINONE and DIIMINOQUINONE—



They are obtained by oxidising para-aminophenol and paraphenylenediamine respectively in ethereal solution with dry silver oxide in presence of anhydrous sodium sulphate to take up water. They are both colourless compounds, and the moniminoquinone is explosive. (2) QUINONEMONOCHLORIMIDE and QUINONEDICHLORIMIDE—

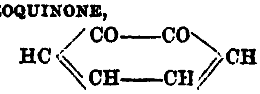


are crystalline solids, which melt at 85° to 124°, and are formed from para-amidophenol and paraphenylenediamine by the action of bleaching powder solution; the monochlorimide is also formed from aniline by hypochlorous acid. The quinoneimides may be regarded as the parent substances of a number of dyes. Thus salts of diiminoquinone form with aromatic amines, and with phenols Indamines (*q.v.*), and indophenols; *e.g.* the simplest indophenol is



(3) ANILIDOQUINONES: When aniline and quinone are boiled in alcoholic solution there is formed dianilidoquinone, $C_6H_2O_2(NHC_6H_5)_2$. The further action of aniline on this compound yields dianilidoquinonedianil, $C_6H_2(NC_6H_5)_2(NHC_6H_5)_2$, also called azophenine. It forms red leaflets, melts at 241°, is insoluble in alcohol and in ether, but soluble in benzene; it is formed in the preparation of indulines (*q.v.*), and is probably an important intermediate

product in the formation of this class of dyes. ORTHOBENZOQUINONE,



forms red plates; melts with decomposition at 60° to 70°, and is obtained by oxidation of orthodihydroxybenzene (catecohol) in dry ether solution by silver oxide. The name quinone is used in combination to denote other substances having a similar constitution to the ortho- and para-benzoquinones. For examples *see* ANTHRAQUINONE and NAPHTHAQUINONES. As all quinones are coloured (yellow or red), the groupings found in these substances are regarded as colour forming groupings: thus diacetyl, $CH_3 . CO . CO . CH_3$, has the orthoquinone grouping, and is yellow in colour. In accordance with this idea many dyes are written with "quinonoid" formulæ. *See, for example,* MALACHITE GREEN, PARAROSANILINE, NEUTRAL RED.

Quint (*Music*). An organ stop sounding the fifth above the open diapason. It is of 5⅓ ft. length on the manuals, and of 10⅔ ft. length on the pedals.

Quintet, Quintett (*Music*). A composition for five voices or instruments.

Quintuplet (*Music*). A group of five notes in the time of four.

Quintuple Time (*Music*). One that has five beats in a bar. *See* TIME.

Quire (*Paper Trade*). Twenty-four sheets of paper. *See* REAM.

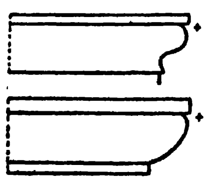
Quired Paper (*Paper Trade*). Sheets of paper folded in quires in contradistinction to paper sent out flat or lapped. *See* REAMS.

Quirewise (*Typog.*) Work printed as alternate pages on single leaves, and folded so as to allow of sewing instead of stabbing through.

Quirk (*Architect.*) An acute channel frequently used in Greek mouldings to separate an ovolo or a cyma reversa from the fillet above. It is also very commonly used in Gothic mouldings.

QUIRKED OGEE.

QUIRKED OVOLO.



—— (*Join., etc.*) The narrow groove at the side of a bead.

Quirk Router (*Join.*) A tool used in cutting a quirk (*q.v.*); it consists of an iron stock resembling that of a spokeshave, with movable cutters or quirking irons of various sizes to suit the width of groove required.

Quoin (*Build., etc.*) An external angle of a wall or building. A corner stone or one that serves to form an angle. A wedge-shaped implement or piece of material.

—— (*Typog.*) A small wedge used in locking up a forme (*q.v.*)

Quotation (*Typog.*) A phrase transcribed from a speaker or author in his own words, and indicated by having two inverted commas at the commencement and two apostrophes at the close, as: "The art preservative of arts."

Quotation Quadrats (*Typog.*) Large metal "spaces" of different bodies used for making up blanks and short pages, and usually cast hollow.

R (*Elect.*) The symbol for RESISTANCE (*q.v.*)

ρ (*Phys.*) A symbol generally used for DENSITY.

R.A. (*Astron.*) RIGHT ASCENSION (*q.v.*)

Rabbet *or* **Rebate** (*Build.*) A groove or slot on the edge or face of a flat surface. It is intended to receive the end or edge of another piece of material. A rectangular recess along a projecting angle, *e.g.* one to receive the edge of a door.

Rabbet Plane (*Join.*) A plane for working a right angled recess or groove on the edge of a piece of wood.

Rabbia, Con (*Music*). With fury.

Rabble (*Met.*) The flat ended but hooked bar used by puddlers in working the charge of iron, as contrasted with the "paddle," which is a straight chiselled edge bar, much the same as the "peeler" used for placing "piles" (*q.v.*) in the reheating or balling furnace.

Rabbling (*Met.*) The process of stirring the fluid iron during puddling (*q.v.*) The long iron rod bent at the end, with which the operation is effected, is termed a RABBLE (*q.v.*)

Race (*Eng., etc.*) (1) The open channel leading water to a water wheel, etc. (2) The path along which the shuttle travels in a loom. *See* RACE BOARD. (3) The space in which a drum or the flywheel of an engine revolves. (4) The path of the rollers or balls in anti-friction bearings, *e.g.* in a cycle wheel.

Race Board (*Weaving*). The smooth board fixed on the loom sley over which the shuttle traverses.

Raceme (*Botany*). An inflorescence in which the main axis bears stalked flowers and is capable of continued growth, adding new flowers in the apical region. An example is seen in the Currant.

Racemic Acid (*Chem.*) A form of tartaric acid composed of equal quantities of dextrotartaric and lævotartaric acids. *See* TARTARIC ACID.

Racemic Form or Modification (*Chem.*) *See* STEREOISOMERISM.

Racer (*Eng.*) A term sometimes applied to certain parts of machines which move with very great velocity.

Racing (*Eng.*) Uncontrolled increase in the speed of an engine when the governor (*q.v.*) fails to act properly. In marine engines racing occurs if the screw propeller is lifted out of the water by the motion of the vessel in rough weather.

Racing Cycles (*Cycles*). Very light cycles fitted with thin tyres, rat trap pedals, and very small saddles.

Rack (*Eng.*) (1) A bar, either straight or slightly curved, with gearing teeth cut on it, employed for converting rectilinear into circular motion, or the contrary. (2) A very general term for an object with a series of projections or equidistant parts of any description in machines, etc.

—— (*Lace Manufac.*) A unit of measurement employed in the manufacture of lace by machinery, *viz.* 240 holes or meshes of net. The system of measurement by which the Twist hand or working lacemaker is paid and by which lace is usually sold when in the "web" or "brown."

—— (*Typog.*) A fixture with grooves or runners for holding formes, cases, boards, etc.

Rack and Pinion (*Eng.*) A device for converting the rotary motion of a shaft into linear motion by means of a small toothed wheel or pinion keyed on the shaft, and gearing with a rack. Frequently used in mechanism.

Rack Back (*Build.*) In building a wall it is sometimes necessary to leave a portion of it unfinished. When this is the case every course is started $2\frac{1}{4}$ in. back from the unfinished part. This is to prevent unequal settlement when the wall is finished.

Racking (*Build.*) A term signifying distortion. If a piece of framing is moved out of shape, it is said to be racked.

—— (*Chem. Manufac.*) The process of running spirit from one vessel to another, so as to expose it to the action of the air in order to promote oxidation, etc. It facilitates the "ageing" of spirit.

—— (*Mining*). The separation of ores, etc., by washing them on a sloping surface.

—— (*Surveying*). *See* SURVEYING.

Rack Rail (*Eng.*) The toothed rail used in certain forms of MOUNTAIN RAILWAY (*q.v.*)

Raddle (*Build., etc.*) Wattled work, *e.g.* a hurdle formed of supple sticks or boughs intertwined between stout upright sticks. A similar structure, formed of laths, and daubed or plastered with clay, is sometimes used to form a wall.

—— (*Weaving*). A coarse kind of sley or reed (*q.v.*), but usually made of wood. Between the pins or pegs the threads of warp are passed in groups in running the warp on to the warp beam or roll.

Raddolcendo (*Music*). Increasing in softness.

Radial Arm (*Eng.*) A projecting lever or arm, pivoted at one end, and usually carrying some mechanism, as in a RADIAL DRILLING MACHINE (*q.v.*)

Radial Drilling Machine (*Eng.*) A drilling machine in which the drill spindle is carried on a projecting arm which can rise and fall or swing round in a horizontal plane, thus allowing the drill to be brought into different positions over the piece of work.

Radial, Radially. Having the direction of a radius, *e.g.* lines, etc., diverging from a centre.

Radian (*Math.*) The unit angle in the system of CIRCULAR MEASURE (*q.v.*)

Radiant (*Astron.*) A point from which the paths of a number of meteors appear to diverge.

—— (*Phys.*) Acting as a source of radiation. The term is sometimes applied to the source itself, *e.g.* the light used in an optical lantern is termed the Radiant.

—— *or* **Rayonné** (*Her.*) A charge or ordinary having rays issuing from the edge.

Radiant Heat. Heat which passes from a hot body or source through an intervening medium which transmits, but does not absorb it. Heat, or, more correctly speaking, radiant energy, travels from the sun to the earth in this manner through the ether, and appears as heat when it falls on a body which absorbs it.

Radiation (*Phys.*) A term denoting the emission of energy from a body.

LIGHT AND HEAT RAYS: In this case the energy takes the form of wave motion in the surrounding ether, originated by the molecular vibrations of the radiating source, and does not become heat or produce the sensation of light until it falls upon a body which absorbs it, or upon the retina of the eye. The process of warming by radiation, as the earth by the sun, thus differs from other possible methods of transferring heat energy, in the fact that the temperature of the intervening space is not affected by the transmission, and is quite independent of that of the source or the receiver. Ether waves only differ from one another in the rapidity of the vibrations; the slower they are the greater the wave length, and *vice versâ.* The waves emitted from a hot solid body are a very complex mixture of different wave lengths, dependent not only upon temperature, but usually also on the nature of the body—that is, some wave lengths are emitted in greater proportion than others. According to modern ideas regarding the structure of matter, all bodies above absolute zero are sources of disturbance in the ether in which they are embedded. It is probably inaccurate to regard the molecular vibrations themselves as originating waves, for ordinary matter moves freely in ether without getting any "grip" on it; it is most likely the oscillations of the attached electric charges or "electrons" which are effective, their period, however, being governed and controlled by the molecules to which they are attached. The properties of the waves thus produced are functions of their period or wave length. Very long waves of slow period, of lengths, say, half inch and upwards, are most easily produced by electrical methods, and are applied to useful purposes in Wireless Telegraphy. The radiation from heated bodies has been traced experimentally through a range of wave length extending from about $\frac{1}{400}$ to $\frac{1}{250000}$ in. At about $\frac{1}{32000}$ in. they become capable of producing the sensation of red light, the greatest heating effect being produced by invisible waves somewhat longer than these. When $\frac{1}{63000}$ in. is reached for the extreme violet the radiation again becomes invisible, and within this range the heating effect has rapidly decreased and the power of producing fluorescence, phosphorescence, and chemical action has increased with equal rapidity. The general laws of radiation were discovered during the earlier and middle part of the last century by Leslie, Melloni, Forbes, Tyndall, and others. Their investigations established the fact that good radiators are also good absorbers, and *vice versâ,* and also that a body when cool absorbs most readily those wave lengths which it most readily emits when hot. But as their methods dealt with complex sources of radiation as a whole, and as these properties vary in general with wave length, no exact quantitative results were obtained. Probably the greatest advance which has been made since the days of the early experimenters has been in the direction of sorting out radiation and dealing with particular wave lengths individually, and also in the conception and realisation of the "absolute black body." Black surfaces possess the property of absorbing or radiating all waves with almost equal freedom; but even lampblack reflects and diffuses some of the radiation which falls upon it, and it becomes therefore possible to imagine an ideal substance which shall neither reflect, diffuse, nor transmit, but completely absorb all the incident waves of whatever kind. The properties of such a body can be investigated mathematically, and among other important results it has been established:

(1) The radiation from it depends only upon its temperature and the refractive index of surrounding

medium, and is quite independent of its nature or physical state.

(2) The energy value of the total radiation emitted per unit area in unit time is proportional to the fourth power of the absolute temperature.

(3) At any given temperature there is one particular wave length which conveys the maximum energy, and this wave length is inversely proportional to the absolute temperature.

(4) The amount of radiation of this particular wave length, for which the energy is a maximum, varies as the fifth power of the absolute temperature,—really a deduction from (2) and (3).

These results afford several methods of measuring very high temperatures, and have been repeatedly verified. No actual substance could satisfy the mathematical requirements of absolute blackness; but a small hole in an enclosure kept at constant temperature realises it in practice, for very little incident radiation is reflected out of it again, and it can be shown to emit the full radiation for that particular temperature. As regards ordinary bodies, it may be said that the higher the temperature the more closely they approximate to the behaviour of the ideal black body.

LIGHT WAVES: It follows from what has been said that light rays differ in no way from other ether waves, except in their special power of stimulating the visual organs, and may form an altogether insignificant fraction of the total emission from a hot body. Their discussion as radiation belongs to the Theory of Light; here it is sufficient to say that solid incandescent bodies give a continuous spectrum, *i.e.* emit waves of all lengths within a certain range, the maxima extending further into the violet as the temperature rises, in accordance with the radiation law (3) already given. Gases and vapours do not usually become luminous by merely rising in temperature; but when caused to emit light by any suitable stimulus, they give, under ordinary conditions, discontinuous spectra, *i.e.* there is selective radiation and consequently there is selective absorption—a fact upon which the whole science of Spectrum Analysis is founded.

PRESSURE OF RADIATION: According to the theory of light there must be a pressure upon any surface due to incident radiation, that due to normal incidence upon a completely absorbent surface being numerically equal to the energy of the wave per unit volume. For a perfectly reflecting surface its value would be twice as great. The absolute value of this pressure is very small (about $4{\cdot}1 \times 10^{-5}$ milligrams weight for sunlight); but it has been detected experimentally by Lebedew, and the results confirmed by Nichols, and in the case of very small particles it may be greater than gravitation. Poynting has detected experimentally the tangential forces which exist in the case of refraction. This pressure of radiation is of great importance in the theory of the absolute black body.

SOLAR CONSTANT: This is the amount of energy (expressed in gram-centigrade heat units) received by 1 square centimetre per minute at the earth's distance from the sun, assuming no atmosphere present. Its value lies probably between 3 and 4. At least 40 per cent. of this energy is intercepted by the atmosphere. A simple calculation shows that the energy radiated per square centimetre per minute from the sun's surface is 460,000 times as much, which works out to about 17 horse power.

CATHODE, LENARD, AND RÖNTGEN RAYS: The first two of these are not radiation in the ordinary sense (not being ether waves), but may be dealt with conveniently here as special cases of emission of energy. Cathode rays are given out by the negative terminal of a vacuum tube at very high exhaustions (of the order of one-millionth of an atmosphere). They were first noticed by Plücker and Hittorf, and afterwards carefully studied by Crookes. This radiation is easily shown to issue normally from a cathode, and to behave as if it were a stream of material particles carrying negative charges and moving with very high velocities (which may amount to from $\frac{1}{10}$ to $\frac{1}{3}$ of the velocity of light). This stream possesses inertia, being capable of turning vanes and of heating the surfaces on which it falls, and many substances become brilliantly phosphorescent with characteristic colours when exposed to its impact. Finally, these properties are completely independent of the nature of the matter present in the tube. Lenard covered a small hole in the tube with very thin aluminium (following up an observation due to Hertz), and found that when a stream of cathode rays fell upon it, something feebly luminous passed through into the outside air which could excite phosphorescence and produce feebly most of the effects of cathode rays, but which became speedily dissipated and lost except close to the origin. It was, in fact, cathode rays which had penetrated the aluminium, and which were found to be capable of penetrating any kind of matter if only thin enough, being stopped by substances roughly in the order of their densities. The study of cathode rays inside the tube naturally suggested the idea of material particles, while, on the other hand, the fact that their properties were independent of the nature of the matter used, and the remarkably penetrating nature of the Lenard rays in air seemed to contradict this hypothesis, for no ordinary atom could move a fraction of an inch in air without being stopped and diverted by frequent collisions. Hence arose two schools of thought, the English physicists on the whole regarding them as charged particles, whilst Lenard and his followers considered them to be a particular kind of ethereal disturbance independent of ordinary matter. Finally, J. J. Thomson, in a most brilliant series of measurements, showed that the cathode stream consists of negatively charged particles having only about $\frac{1}{700}$ of the mass of the hydrogen atom, and which, although derived from ordinary matter, are certainly not matter in its ordinary sense. This result, together with their high velocity, explains their penetrating power, and constitutes an epoch in our knowledge of the structure of the atom. Röntgen discovered that when cathode rays are suddenly stopped by striking an obstacle, a new and still more penetrating kind of radiation emanates from the point struck, which, although invisible to the eye, can pass through the glass of the tube and affect photographic plates or excite phosphorescence outside. Like Lenard rays, it is stopped by bodies roughly in the order of their densities, but differs from them in being perceptible at enormously greater distances from the tube. This radiation possesses conspicuously the power of strongly ionising air or other gases through which it passes, making them temporarily conductors. Further, it is incapable of being refracted or regularly reflected, and no definite results of the nature of interference or polarisation have been detected. The great range of these rays seems to exclude the idea of projected material particles, and they are generally supposed to be really a special kind of ether wave, not produced in regular vibrations, but as an irregular series of discrete

pulses produced by the shock of the impact of the cathode rays. The question would be practically settled by a determination of their velocity, but it is doubtful if this has really been successfully accomplished at present.—E. E. B.

Radiation, Solar (*Astron.*) Expressing this in energy, it is nearly 130,000 horse power continuously for each square metre of the sun's surface. The Earth receives only about $\frac{1}{2200000000}$ of the total radiation.

Radiator (*Build.*) A hollow frame or structure, generally of cast iron, through which steam, hot water, or hot air circulates. The heat is radiated into the apartment in which the structure is fixed, thus warming it. Where feasible, radiators should be fixed against an outer wall and be furnished with a device for admitting air from without; this becomes heated as it passes over the surface of the radiator, and keeps the atmosphere of the apartment fresh.

—— (*Eng.*) A device for dispersing heat by radiation; *e.g.* the apparatus by which the circulating water in a motor car is cooled. *See* MOTOR CAR *and* PETROL ENGINE.

Radical (*Chem.*) Literally the common stem or root of a number of different compounds. It is used occasionally of elements. Thus, when it is desired to refer to the metal in a series of salts of that metal, the metal might be spoken of as the basic radical. But the term is much more commonly used to denote a group of elements which reacts as if it were a single element; such groups are known as compound radicals, and have not an independent existence. Thus the group CN is the cyanogen radical, but it does not exist by itself. However, two such groups usually unite together to form a compound which can exist. Thus we have:

Methyl, CH_3	Ethane, CH_3-CH_3
Cyanogen, CN	Cyanogen, Gas, $CN-CN$
Phenyl, C_6H_5	Diphenyl, $C_6H_5-C_6H_5$

See also COMPOUND RADICAL *and* CACODYL.

Radicle (*Botany*). The descending portion of the axis of the embryo in a seed. It absorbs nutritive solutions from the soil, and also gives anchorage to the seedling. In most Dicotyledons the radicle develops into the main or tap root of the adult plant; but in Monocotyledons it is suppressed, and roots arise from the base of the stem.

Radio- (*Phys.*) Relating to rays or radiation, *e.g.* RADIOACTIVITY (*q.v.*)

Radioactivity (*Phys.*) The power possessed by certain substances of spontaneously emitting radiations capable of affecting photographic plates, exciting phosphorescence, and ionising the surrounding air.

In 1896 Becquerel discovered that uranium salts emitted something which could act upon a sensitive plate wrapped up in black paper, and which made the air around temporarily a conductor. He found that all salts of uranium, and also the metal itself, possessed these properties, which in no way depended upon previous exposure to light and were in no degree weakened by lapse of time. He also found that the radiations could not be reflected, refracted, or polarised, while researches by various experimenters showed that of the known elements only thorium possessed similar powers.

The next great step was made by M. and Madame Curie, who found that while all uranium minerals were active, their activity was not proportional to the amount of uranium they contained, and in some cases was even greater than that of the metal itself. This suggested that small quantities of some very active substance were present, and after much labour M. and Madame Curie were able to separate from PITCHBLENDE (a very complex ore of uranium) two intensely active substances now known as RADIUM and POLONIUM, the former being a definite element allied to Barium, and the latter a substance associated with bismuth, difficult to isolate and as yet of uncertain nature. Other radioactive bodies have been separated from pitchblende, but in quantities excessively small, and it is still doubtful how far they are really independent entities. Debierne obtained ACTINIUM, and Marckwald RADIO-TELLURIUM, while Hofmann and others have found an active substance present with lead derived from that mineral.

Radioactivity is detected either by its effect on a sensitive plate or by its power of discharging charged bodies, the latter method being by far the more delicate and reliable. It appears to be due to the gradual breaking up of a complex atom into simpler forms, accompanied by the emission of relatively enormous quantities of energy. Very little of this emitted energy is in the form of ordinary light or heat waves, although the emission keeps the source at a perceptibly higher temperature than its surroundings. It mainly consists of streams of charged particles projected with great velocities. Such a stream is deflected by magnetic and electric fields, and the amount of the deflection in the two cases determines the velocity and ratio of mass to charge of the flying particles. Three distinct types of radiation were soon recognised and distinguished as the α, β, and γ-rays respectively, all of which are given off by Radium and Thorium: whereas Polonium and Radio-Tellurium appear to give off mainly one kind, the α-rays.

The α-rays represent most of the radiated energy, and appear to be positively charged particles about twice as heavy as the hydrogen atom, and moving with velocities of about 20,000 miles per second. They excite phosphorescence in certain substances, especially Sidot's Blende (*q.v.*), and their ionising power is very great. They are only slightly deflected by a magnetic field, and are very easily stopped by slight obstacles, such as a sheet of paper.

The β-rays appear to be identical with Cathode rays. They consist of negatively charged particles much smaller than ordinary atoms, moving with velocities varying from about 50,000 miles per second to a speed closely approaching that of light itself. They are easily deflected by magnetic and electric fields, can excite phosphorescence, especially in Willemite, Kunzite, and barium-platinocyanide, and can readily penetrate obstacles which would entirely stop the α-rays. At the same time their ionising power is much less than that of the α-rays.

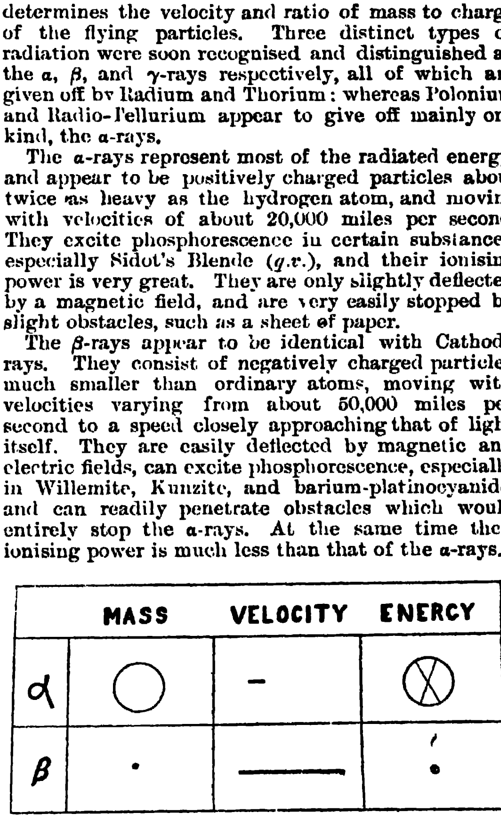


FIG. 1.

Diagram showing the mass, velocity, and energy of the α and β particles. The velocity is represented by the length of the lines in the middle column, the mass and energy by spheres.

The γ-rays do not appear to consist of material particles, as they are not deflected by magnetic or electric fields. They are probably a special kind of ether wave, *i.e.* of light, resembling X-rays, and are produced by the shock of starting the emitted particles, just as ordinary X-rays in a vacuum tube are produced by their sudden stoppage. Their chief characteristic is their remarkable power of penetration, in which respect they surpass the X-rays. They also possess the power of exciting phosphorescence and causing ionisation, but in the latter respect are less effective than the β-rays and enormously less effective than the α-rays.

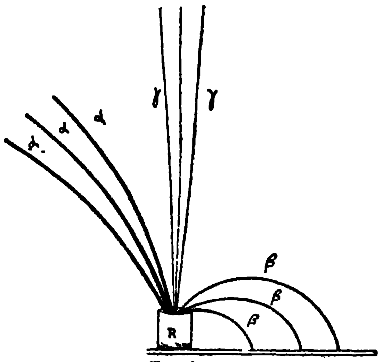


FIG. 2.

Diagram showing the deflection of the α, β, and γ Rays from Radium.

In addition to these typical forms, it has been recently shown by J. J. Thomson and others that there is also a copious emission of quite slow moving β-particles. These complex radiations are not emitted by Thorium, Radium, or Uranium themselves, but by substances continually being formed from them, and which by suitable means can be removed from the parent substance, leaving an inactive material which regains its radioactive power at a perfectly definite rate.

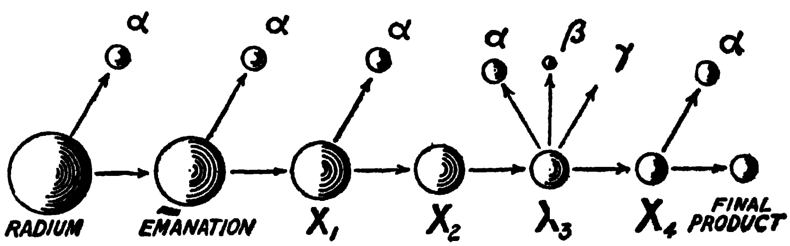


FIG. 4.

Diagram representing the disintegration of a Radium Atom.

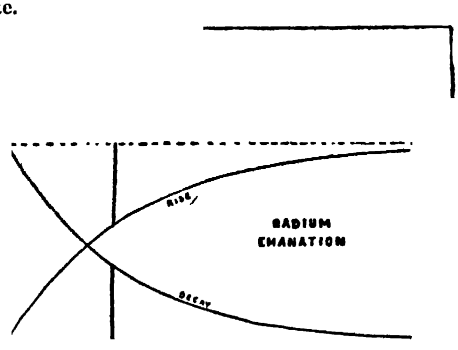


FIG. 3.

Curves showing the rate of decay of the activity of the emanation, and the recovery of activity of Radium.

Meanwhile the very active portion removed gradually loses its activity at exactly the same fate, differing for different substances, but always in a geometrical ratio with time. For this reason it is convenient to state the time required for the body to lose half its activity, for this is a definite period, whatever the initial strength may be. It will be sufficient here to trace the life history of radium as far as at present known.

The parent of radium is probably uranium, from which it is formed at a very slow rate—so slowly that this fact is as yet not definitely established. Radium itself does not appear to be radioactive, but in its turn slowly breaks up, giving off in minute amount an "emanation" (discovered by Rutherford first in the case of thorium), which mostly remains occluded in the parent radium salt, from which it can be removed by heating or bubbling air through a solution. This "emanation" appears to be an inert heavy gas, displaying no chemical activities, and absolutely unaffected at the highest temperatures. It can be liquefied by cold and pumped through tubes, and it apparently has a characteristic spectrum. It is intensely radioactive, its presence in glass tubes being indicated by the phosphorescence of the walls, and it supplies most of the heat emission of radium salts (according to Rutherford, if it were possible to collect a cubic inch, it would probably melt the glass tube containing it), and it appears to emit only α-particles. It loses half its activity in four days, which means that in that time half of it has changed into some other form. Apparently this change is due to the emission of the α-particle, and it now becomes "emanation X_1," a solid body which collects on surfaces exposed to the gaseous emanation, leaving them temporarily radioactive after the latter has been blown away. In three minutes half of this changes into "emanation X_2," also with the emission of α-particles. X_2 does not appear to emit any kind of particle; but every twenty-one minutes half of it changes into X_3, which in its turn breaks up rapidly (half in twenty-eight minutes), with the emission of α, β, and γ-rays. It is noteworthy that the β and γ-rays are only emitted during the last of these four rapid changes.

The next two stages occur very slowly, and have only recently been traced by Rutherford, who calls them provisionally D and E. The former only gives out β-rays, and is half transformed in about forty years into E (however, it may eventually turn out that two changes occur here instead of one). E gives out only α-rays, and is half transformed in about 150 days. Beyond this nothing is as yet known with certainty. These slow changing bodies should gradually accumulate in ores of radium, and it is possible that D may turn out to be the active constituent in Hofmann's radioactive lead, while E may be identical with the polonium of the Curies and the radio-tellurium of Marckwald. Only the first product of radium, the gaseous emanation, is

chemically inert. All the succeeding solid products have definite chemical and physical properties, which make it possible to identify and partially separate them. What the final products may be is as yet unknown; but it is certain that the rare gas HELIUM is one of them, and it may possibly be the projected α-particle itself. This formation of helium from radium (discovered by Ramsay and Soddy) is remarkable as being the first case known of one element changing partly into another. Evidence is rapidly accumulating which goes far to show that radioactivity is in various degrees a general property of matter, and not confined to a few very rare substances. Apparently the whole crust of the earth is more or less radioactive, and it seems probable that slow and gradual change into simpler forms is part of the life history of the atom.—E. E. B.

Radiograph. (1) An instrument for measuring and recording the intensity and duration of sunshine. (2) An image of some object produced on a sensitised plate by means of the Röntgen rays.

Radiolarian Ooze *and* **Radiolarian Chert** (*Geol.*) Large numbers of *Polycystinæ* (*Protozoa* with siliceous tests) live in the upper waters of the warmer parts of the ocean along with the *Foraminifera*, which secrete calcareous shells. When these die their shells descend together towards the ocean floor. But solution of the calcareous shells begins at a few hundred fathoms below the surface, and is generally completed by the time they have sunk to a depth of 2,500 fathoms. The siliceous shells of the *Radiolaria* or *Polycystinæ* then reach the bottom alone, *i.e.* without any calcareous matter. A deposit so formed is termed a Radiolarian Ooze. Ancient Radiolarian Oozes, now altered into more or less cherty rocks, occur in many geological formations, and bear important testimony to the former presence of oceanic conditions in areas which may now form parts of continents.

Radiometer, Crookes' (*Phys.*) A set of light metal vanes, fixed on a vertical axis so as to be capable of easy rotation, and enclosed in an exhausted globe. One side of each of the vanes is blackened, the other left bright. Radiant heat received by the vanes causes them to rotate at a rate depending on the intensity of the radiation.

Radio Micrometer (*Elect., etc.*) An instrument for the detection and measurement of small amounts of radiant heat. It consists of two small bars of metal forming a thermo-electric couple (*q.v.*), one end of each bar being attached to a small blackened copper disc on which the radiant heat is received, and the other ends connected together by a loop of copper wire. The whole arrangement thus forms a closed circuit, and is suspended by a quartz fibre in the strong magnetic field between the poles of a magnet such as is used in suspended coil galvanometers. Radiant heat falling on the disc heats the thermo-electric junction, causing a current to flow round the loop, and the whole circuit turns through an angle depending on the strength of the current, *i.e.* on the intensity of the radiation received. The instrument is extremely sensitive, and when used with a suitable reflector will detect the radiant heat received from a candle placed two miles away.

Radium (*Chem.*) Rd. Atomic weight, 225. A metal which occurs, in traces only, in pitchblende, carnotite, and a few other rare uranium-containing minerals. The pitchblende (*q.v.*) from Joachimsthal (Bohemia) contains more radium than any other variety. After the uranium has been extracted from this pitchblende, a ton of the residue yields 0·2 to 0·3 gram of radium bromide. The metal itself has not been prepared; but it amalgamates with mercury, as is shown by the fact that when a saturated solution of radium-barium chloride is shaken with a 1 per cent. sodium amalgam, a radium-barium amalgam relatively richer in radium than the original double chloride is formed, so that the metal could be prepared by means of its amalgam. *Cf.* BARIUM. A number of radium salts have been prepared, *e.g.* the bromide, chloride, nitrate, carbonate, and sulphate, and they resemble generally the corresponding barium salts; but the bromide and chloride are less soluble than those of barium, and of course no barium salt is radioactive. Radium bromide is prepared from pitchblende by the following method. The pitchblende is powdered and fused with sodium carbonate. Soluble salts are extracted with hot water, and the residue is treated with dilute sulphuric acid. The sulphuric acid solution contains the uranium. The insoluble residue, formerly a waste product, contains the radium; it is treated with concentrated hydrochloric acid. The solution thus obtained contains most of the polonium and actinium, while the insoluble part contains the radium in the form of sulphate. After washing with water, this residue is boiled with a concentrated solution of sodium carbonate, in order to transform the insoluble sulphates to carbonates; the carbonates are washed with water, then dissolved in dilute hydrochloric acid. This solution is again precipitated with sulphuric acid, and the resulting sulphate converted into chloride exactly as above. The solution of chlorides is now treated with sulphuretted hydrogen; the precipitate contains some polonium. The solution is boiled and oxidised by potassium chlorate, and treated with ammonia; the precipitate contains some actinium. The solution is precipitated by sodium carbonate, the precipitate is washed, dissolved in hydrochloric acid, evaporated to dryness, and the residue washed with concentrated hydrochloric acid to remove calcium chloride, and leave a residue of barium and radium chlorides. A little radium is removed by the washing with hydrochloric acid; it is precipitated by sulphuric acid, and the precipitate worked up with fresh material. The radium and barium chlorides are dissolved in water, precipitated by sodium carbonate, and the carbonates dissolved in hydrobromic acid. Eight to ten kilograms of mixed bromides result from 1,000 kilograms (2,204 lb.) of pitchblende, and it is about sixty times as active as uranium. The bromides are now submitted to fractional crystallisation, first from water, then from hydrobromic acid, the radium bromide being less soluble than the barium bromide. The most active bromide obtained is about two million times as active as uranium. Radium bromide crystallises in the monoclinic system, is deliquescent, and is therefore kept in sealed tubes; it gives a crimson colour to the Bunsen flame, and when this flame is viewed in the spectroscope it gives two lines in the red, one in the blue green, and two (faint) in the violet. On keeping, the radium bromide, which is pure white when fresh, becomes brown; but it can be made white again by heating. A solution of radium bromide in water evolves hydrogen and oxygen continually at the rate of 10 cc. of the mixed gases per gram of radium per day, the hydrogen always being rather more than double the volume of the oxygen. Radium salts convert yellow phosphorus into red phosphorus. When exposed to air, ozone is

produced; iodine is liberated from a solution of iodoform. They impart a brown violet colour to glass, blacken a diamond externally, also darken quartz. When a radium salt contained in a celluloid capsule is placed on the skin and left a while, its action can be felt, and some hours after its removal a red patch appears, then a wound, which takes a long time to heal. On this account radium salts have been applied to the cure of lupus. Attempts have been made to cure cancer by the application of radium salts, but without success. Radium salts cause a number of substances to fluoresce, especially barium platinocyanide, willemite (zinc orthosilicate), Sidot's blende (slightly impure zinc sulphide). A radium salt is feebly luminous in air, and the spectrum of this light has been shown to be that of nitrogen, but in an atmosphere free from nitrogen the spectrum is continuous. Radium is an element which is constantly undergoing spontaneous decomposition; its atom is not stable, but breaks up into simpler atoms. This decomposition differs from ordinary chemical decompositions in being entirely beyond the control of the chemist, who can neither accelerate nor retard it. The rate of this decomposition is such that a gram of radium bromide would be half decomposed in about 1,150 years; the nature of the decomposition is described under RADIOACTIVITY (*q.v.*) As radium has a comparatively short life, it follows that, in a mineral such as pitchblende, radium is constantly being produced. Its probable source is uranium, itself a radioactive element, but with a much longer life (2,000,000,000 years). There is little direct evidence bearing on this subject as yet; but it is noteworthy that the amounts of uranium and radium present in pitchblende are about as $10^9:10^3$. The physical behaviour of radium is described in the article on RADIOACTIVITY (*q.v.*) The atomic weight of radium has been determined by precipitating a solution containing a known weight of radium chloride with silver nitrate, and weighing the silver chloride so produced; the value obtained was 225 (O = 16). It has also been determined by comparing the frequency difference of the double lines in the two subordinate series of the radium spectrum with those of magnesium, calcium, strontium, and barium; the result is 257·8. The reason of this great difference is unknown. That radium is an element is shown by the fact that it falls into position in the periodic system (*q.v.*); it has chemical properties closely resembling those of barium, which is an element in the same group; it has a characteristic spectrum.

W. H. H.

Radius. In a circle, the distance from the centre to the circumference. *See also* RADIUS OF CURVATURE.

Radius of Curvature. If normals be drawn from two adjacent points on a curve, they will intersect in a point lying on the concave side of the curve. If the two points be now supposed to move towards one another, the point of intersection of the two normals will move towards a limiting position, which it will occupy when the two points from which the normals are drawn are upon the point of coinciding. The distance from the curve to the point of intersection of the normals is termed the RADIUS OF CURVATURE of the curve. The point of intersection is the CENTRE OF CURVATURE, and a circle drawn from this centre, touching the curve at the points from which the normals are drawn, is termed the CIRCLE OF CURVATURE of the given curve at the point of contact. It has at this point the same *slope* and the same *rate of change of slope* as the given curve.

Radius of Gyration (*Phys., etc.*) The Moment of Inertia (*q.v.*) of a body may in general be expressed in the form $K = mk^2$, where m is the mass; the quantity k is called the Radius of Gyration.

Radius of the Earth (*Astron.*) The mean or average radius is about 3,959 miles. Measured from the Pole to the centre it is 3,950 miles; from the Equator to the centre it is 3,963 miles. The earth is really an oblate spheroid, *i.e.* a solid produced by an ellipse revolving about its shorter axis.

Radius Rod (*Eng.*) Part of the Parallel Motion used in beam engines; now nearly obsolete.

Radius Vector (*Phys., etc.*) A line drawn from a fixed point to a particle or body moving under the influence of a force acting towards that point; *e.g.* the line drawn from a planet to the sun.

Raffia (*Botany*). The thin cuticle (or outer wall of the epidermis) of the leaves of a Madagascar palm, *Raphia ruffia* (order, *Palmæ*), used by gardeners for tying up plants, flowers, etc.

Raffinose (*Chem.*) $C_{18}H_{32}O_{16}$ (Melitose or Melitriose). A sugar which crystallises in shining needles or prisms containing 5 molecules of water of crystallisation. On slow heating at 80° to 105° it loses this water and forms an anhydride. Soluble in water; insoluble in alcohol; no sweet taste; its solution is dextrorotatory $[\alpha]_D = 404°$. On hydrolysis with dilute acids it yields dextrose, lævulose, and galactose:

$$C_{18}H_{32}O_{16} + 2H_2O = 3C_6H_{12}O_6.$$

On careful hydrolysis an intermediate stage occurs, lævulose splitting off first and melibiose being formed, $C_{18}H_{32}O_{16} + H_2O = C_6H_{12}O_6 + C_{12}H_{22}O_{11}$. Raffinose has no reducing properties, and therefore forms no osazone. Nitric acid oxidises it to oxalic, saccharic, and mucic acids. It forms an endeca-nitrate and an endeca-acetate. Like cane sugar it unites with calcium, barium, and strontium oxides. It is not inverted by diastase; but it is inverted to lævulose and melibiose by invertase; and another yeast enzyme (meliboglycase) inverts the melibiose. Zymase slowly, but completely, ferments it. Raffinose occurs in eucalyptus-manna, in cotton seeds, and in beetroot sugar molasses. It can be obtained from the manna by repeatedly extracting it with boiling water and some animal charcoal and purifying the product by recrystallisation from dilute alcohol.

Rafters (*Build.*) The timbers to which the roof covering is fixed. *See* ROOFS.

Rag. (1) The name given to various kinds of stone found in different parts of England, and used for building purposes; *e.g.* Kentish rag. *See* BUILDING STONES. (2) A large roofing slate with one side rough.

Rag Bolt (*Build.*) (1) A bolt with an enlarged end for bedding in masonry. (2) A bolt with barbs or jags in the direction of the head, so that it cannot be withdrawn after being driven in.

Rag Grinding (*Mango or Shoddy Manufac.*) The operation of reducing rags made of wool, worsted, or mixed materials to fibre. Done by a rag grinding machine.

Raglet (*Build.*) A groove cut in a wall, into which the edge of flashing (*q.v.*) is turned.

Raguly *or* **Ragulée** (*Her.*) Having projections. A dividing line similar to "embattled," but with the projections slanting. *See under* HERALDRY.

Rail (*Carp.*) A general term for a horizontal member in a framed structure.

—— (*Eng.*) Applied in a general sense to a long bar, especially to a bar along which the wheels of a vehicle run. Rails are described according to the kind of line for which they are used, and are further distinguished according to cross section as Double Headed Rails, etc. *See under* RAILWAYS.

Rail Bender (*Eng.*) A massive clamp used for bending rails to an arc of a curve. The force necessary to bend the rail is applied by a screw or by hydraulic pressure.

Rail Bond (*Elect. Eng.*) An electrical connection established by means of conductors, usually of copper, between the adjacent ends of two lengths of rail in electric traction.

Rail Clamp (*Eng.*) A clamp or bracket used to hold a ratchet drill (*q.v.*) in place when a rail is being drilled; by this means a hole can be made in a rail while it is in position.

Rail Fagot (*Eng.*) A FAGOT or pile (*q.v.*) of bars of different qualities of iron, which is to be used for rolling rails. Fagoted iron rails are now almost superseded by steel rails.

Rail Gauge (*Eng.*) A measuring bar used in fixing rails the proper distance apart.

Rail Guards (*Eng.*) Bars fitted to the front of the frame of a locomotive, and reaching nearly down to the rails. Their purpose is to remove obstacles from the surface of the rails.

Rail Ingots (*Eng.*) Ingots of Bessemer steel about 1 ft. square, from which steel rails are rolled.

Rail Tests (*Eng.*) Rails are usually tested by allowing a heavy mass of specified weight to fall on a rail resting on two supports. The amount of deflection is noted, and from this, in conjunction with chemical tests, the quality of the rail can be estimated.

Railways. Early in the seventeenth century an inventive genius, with a view to reduce frictional resistance on roads, hit upon the idea of laying down parallel blocks of timber for the wheels of vehicles to travel on, thus forming a TRAMROAD, in the neighbourhood of coal and iron mines. No marked strides seem to have taken place until about a century later, when the wooden blocks were abandoned in favour of cast iron plates, which were secured to iron shoes bolted to stone blocks. Vehicles drawn by horses, and fitted with flanged wheels, travelled on these plates; but this road proved much too rigid, and eventually the stone blocks were replaced by timber sleepers, and the cast iron plates by wrought iron rails. The application of STEAM as a motive power was assuming practical lines early in the nineteenth century, leading to further improvements and developments of the tramroad, which was now merging into the dignity of a railroad. In 1821 a line was opened for goods traffic between Stockton and Darlington, followed in 1830 by the first railway designed for passenger traffic, *viz.* from Liverpool to Manchester, engineered by the famous George Stephenson. The line was a double one, and the motive power the historical engine "Rocket," made by Stephenson. This enterprise proved an immediate financial success, resulting in an enormous development in the construction of railways, the movement quickly spreading to the Continent and America and gradually to every part of the globe. It is scarcely possible to realise the full importance of the introduction and extension of railways as a factor in the world's progress and advancement.

Approximately, the present MILEAGE (1905) is 534,300, distributed as follows:

	Miles.
Europe	186,720
Asia	46,530
Africa	15,560
N. America	239,020
S. America	29,860
Australia	16,610
Total	534,300

The capital involved is nearly £8,000,000,000 (eight thousand millions). In the United Kingdom the mileage is 22,435, the capital £1,245,629,000, and the approximate number of people employed 500,000. In this country the construction of railways is controlled by various Acts of Parliament, and before a new line can be opened for passenger traffic the Board of Trade must certify that it has been properly constructed and equipped and all rules and regulations complied with.

CONSTRUCTION.—In laying out a railway the cuttings should as far as possible balance the embankments, consistent with workable curves and gradients. On the earlier railways gradients were seldom constructed steeper than 1 in 200, nor curves sharper than 60 chains' radius; but with the improvements in the permanent way and engines and the introduction of machine brakes, gradients of 1 in 50 and curves of 15 chains' radius became common. These limits are greatly exceeded on mountain railways, where gradients of 1 in 4 and curves of about 300 ft. radius are frequent, such steep gradients being workable by the "Abt" or the "Fell" System, or some form of rack and pinion, and the provision

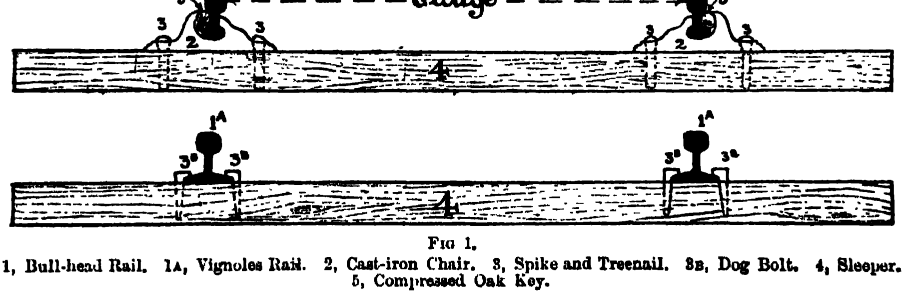
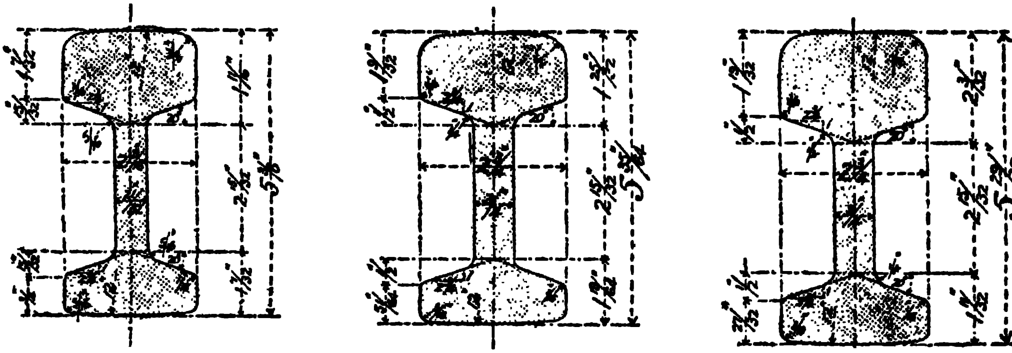


FIG 1.
1, Bull-head Rail. 1A, Vignoles Rail. 2, Cast-iron Chair. 3, Spike and Treenail. 3B, Dog Bolt. 4, Sleeper. 5, Compressed Oak Key.

of powerful machine and automatic brakes. The FORMATION is the prepared surface in cutting or embankment ready to receive the ballast and permanent way. The slopes or batter of the sides of the cuttings and embankments vary with the geological formation passed through. For ordinary soil the most usual is a batter of 1½ horizontal to 1 vertical, but in some kinds of clay the slopes may reach 3 or 4 to 1, whilst a cutting in rock may have vertical sides. The width of formation for a single line is 18 ft. and for a double line 30 ft. A layer of broken stone or coarse gravel 12 in. deep is first placed on the formation, upon which rests the PERMANENT WAY. The modern practice is to place sleepers 9 ft. long × 10 in. × 5 in., generally creosoted (*see* CREOSOTE) about 2 ft. 6 in. apart. Cast iron chairs weighing from 30 to 50 lb. are fastened to these sleepers by spikes and treenails, through-bolts or coach screws, and the RAILS are placed in these chairs and secured by compressed oak keys. *See* fig. 1. In Great Britain the form of rail favoured is the Bullhead, varying in weight from 65 to 100 lb. per lineal yard. Following the American practice of STANDARDISING, which has resulted in many advantages, a committee (Engineering standards) of experts consisting of well known English engineers and others, have recently decided upon a standard rail, both as regards manufacture and dimensions. *See* Fig. 2, which gives three of the standard sections. In future the rails used in this country will comply with the suggestions of the committee. They will be manufactured of steel made by the Bessemer or Siemens-Martin process and to the following limits in chemical composition, *viz.*:

Carbon	0·35 to 0·5 per cent.
Manganese . . .	·7 to 1·0 „ „
Silicon not to exceed .	0·1 „ „
Phosphorus . . .	0·075 „ „
Sulphur	0·08 „ „

On the Continent and America the type of rail mostly used is the Vignoles or Flat Bottom (fig. 1). Chairs are not necessary with these rails; they rest either directly on the sleepers, or sometimes a sole plate of thin wrought iron is placed between the rail and sleeper to prevent the rail squeezing into the latter. Rails are usually 30 ft. in length, although 45 ft. is a dimension now becoming general on important lines. The joints are secured by a pair of plates (Fishplates) from 1 ft. 6 in. to 2 ft. in length, with four bolts from ⅞ in. to 1 in. diameter, provision being made for expansion and contraction by slotted holes in the rails. In countries where timber is scarce, or where it is attacked by ants (*e.g.* India) sleepers made of wrought or cast iron are used. The ORDINARY GAUGE in Europe and America is 4 ft. 8½ in. In Ireland it is 5 ft. 3 in., and India 5 ft. 6 in. NARROW GAUGE varies from 1 ft. 6 in. to 3 ft. 6 in., a very large mileage being on the metre gauge (3 ft. 3⅜ in.) The JUNCTION of one line of rails with another is effected by means of switches or points (fig. 3). These are tapering movable rails. The intersection of one rail with another is termed a CROSSING. In America it is termed a FROG (fig. 3). To insure the safe movement of trains, SIGNALS and signal boxes are provided at stations, and also at intervals between them. The signals are usually worked by manual labour by means of levers, and are so arranged that it is not possible to lower a signal for the passage of a train unless the points are properly set, locked in position, and all conflicting signals at "danger." This is termed "interlocking." *See* fig. 4. At present



80 LBS PER YD. 90 LBS PER YD. 100 LBS PER YD.

FIG. 2.

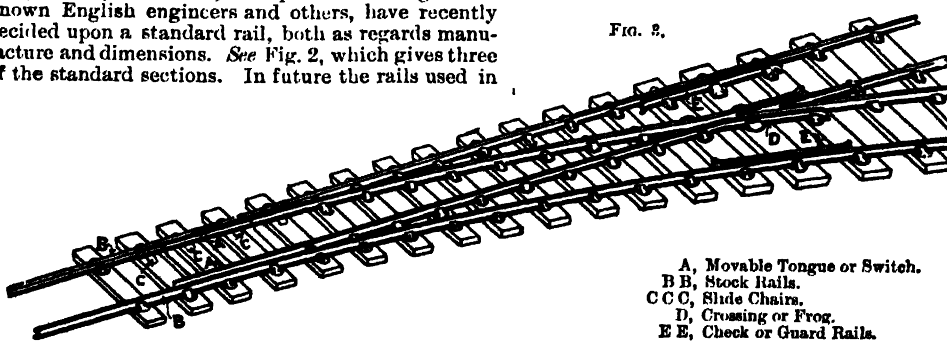


FIG. 3.

A, Movable Tongue or Switch.
B B, Stock Rails.
C C C, Slide Chairs.
D, Crossing or Frog.
E E, Check or Guard Rails.

power signalling is coming into favour, the power being either compressed air or electricity, in lieu of manual labour. A further development is the automatic signalling. Briefly described, this system is as follows (fig. 5): The line is divided into sections of about one mile, and the rails at these points are insulated by means of a special block joint. Every such length forms a distinct section from block to block with the signals controlling it, the intervening joints as to ensure the distant signal remaining at the "on" or danger position until the home signal on the next forward post has returned to the "off" or alright position after the train has passed out of the next adjoining section. Fig. 5 shows a diagram of one section of a line with an automatic pneumatic signalling installation. Doubtless automatic signalling will be extensively adopted in the near future on main lines. It not only increases the carrying

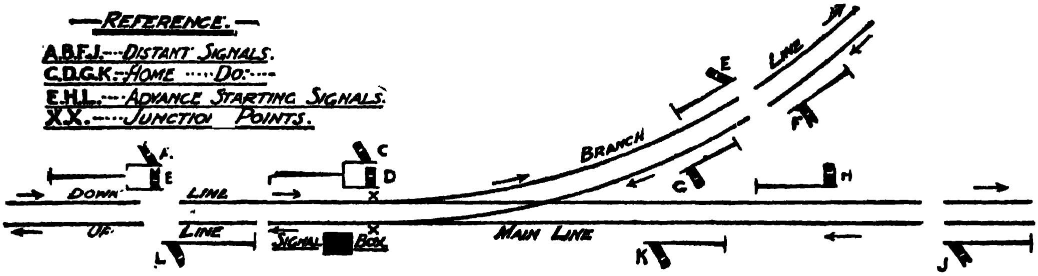


Fig. 4.—Signals.

The road is set for a down branch and up main train; and before Signals A C E J K and L can be lowered, the Points at X X must be locked over in position, and all conflicting Signals must be at the danger position as shown.

being bonded (*i.e.* electrically connected) by means of copper or other suitable wire. The semaphore signals are placed in proximity to the bonded joints, and are moved by levers actuated by compressed air, controlled by valves. The latter are operated by electro-magnets, working with relays (*q.v.*) on the rail or track circuit. A track battery is connected in circuit with the rails, and placed at the end farthest from the signals; a low voltage current is transmitted through one rail to a relay against the signal and through this relay back to the battery along the other rail. A signal battery having a circuit through the contact joint on the track relay, capacity of the line, but tends to greater safety in working.

In no detail has greater strides been made than the Locomotive. From a machine weighing 4½ tons, working at a steam pressure of about 50 lb. and capable of hauling some 20 tons, we now have engines exceeding 100 tons, with a weight of 20 tons on the driving axle, working at a pressure of about 240 lb. per square inch, and capable of hauling 500 tons and upwards. In America goods trains weighing as much as 3,000 tons are not uncommon. To facilitate the working of traffic at goods stations numerous mechanical devices are used, such as steam,

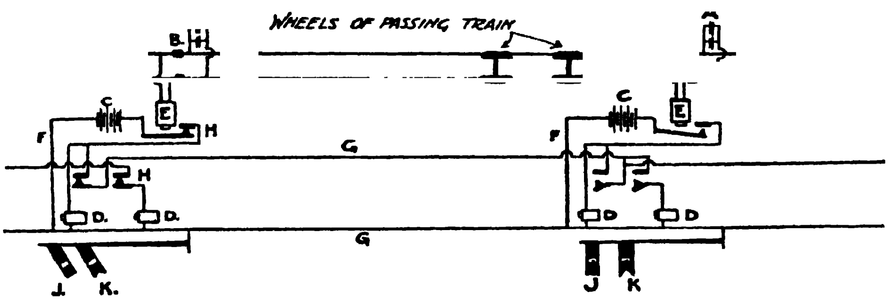


Fig. 5.—Automatic Signalling.

A A, Track Battery. B B, Insulated Joint. C C, Main Battery. D D D D, Electro Pneumatic Valves. E E, Relay Coil. F F, Wire Return. G G, Line Wire. H, Circuit Breaker. J J, Home Signal. K K, Distant Signal.

operates an electro-pneumatic valve by means of the electro-magnet. Assuming there is no train on the line, the signals stand at the "alright" or "off" position by reason of the air pressure in a cylinder actuating the semaphore. This compressed air is generated at a central generating station, and conveyed along the railway by means of a small iron main. When a train enters a section the track circuit is broken down by the wheels and axle forming a short circuit; the relay is now de-energised. This has the effect of closing the valve supplying the air, and the semaphore goes to the "danger" or "on" position by gravity. Circuit breakers are so arranged hydraulic, and electric cranes, hydraulic capstans, turntables, and hoists.

Brakes.—The block system in connection with the working of railways is compulsory in this country, as is also the use of automatic continuous brakes on passenger trains. There are several such brakes, but only two in general use, *viz.* the Westinghouse Automatic and the Automatic Vacuum. Shortly described, the former is worked by compressed air obtained from a small compressor fixed on the engine, which compresses air to about 80 or 100 lb. per square inch. Fig. 6 gives a diagram of the working of the brake. The compressed air is stored in a main reservoir

fixed under the engine, and from this it is conveyed by a main pipe the whole length of a train. Branch pipes connecting with a triple valve, subsidiary reservoir, and brake cylinder are fixed under each vehicle, and two brake blocks are usually placed against each wheel. The brake cylinders are provided with a pair of pistons held together by spiral springs, and under normal conditions the main pipe and reservoirs are charged with compressed air which is shut off from the brake cylinders by means of the triple valve, and equilibrium is maintained. To apply the brakes the driver or guard opens a valve which reduces the pressure in the main pipe, opening

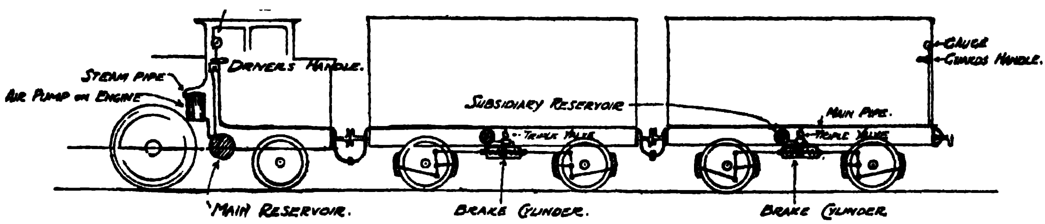


Fig. 6.—Westinghouse Automatic Brake.

the top port in the triple valves and causing the air in the subsidiary reservoirs to enter the brake cylinders between the two pistons, forcing them asunder, and actuating the brake blocks by rods and levers. A similar operation takes place automatically should a vehicle become detached accidentally, as the main pipe is thereby severed. By opening a valve between the main reservoir and main pipe the pressure is restored, the brake blocks return to their normal position and equilibrium again obtains. The action of this brake is very rapid; trains travelling at great speed can be pulled up in little more than their own length. Fig. 7 shows diagrammatically the working of the Automatic Vacuum Brake. This consists

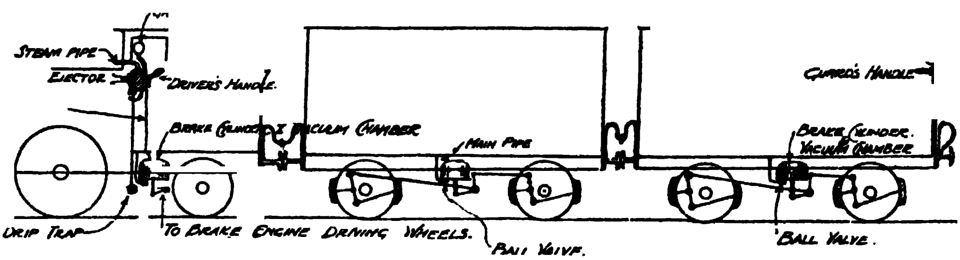


Fig. 7.—The Vacuum Automatic Brake.

of an ejector placed on the engine connecting with brake cylinders and vacuum chambers, fixed under each vehicle by a main pipe which extends the whole length of the train, terminating in the guard's van. The brake cylinders are fitted with a piston connected with brake blocks on each wheel by means of rods and levers in a manner somewhat similar to the last described brake. Before starting a journey the driver operates the ejector which creates a vacuum in the main pipe and brake cylinders, equilibrium then obtains, and the brake blocks hang free. To apply the brakes the driver or guard opens a valve admitting air at atmospheric pressure into the main pipe, which enters the brake cylinders and forces the piston upwards: this in turn actuates the brake blocks. To restore equilibrium and remove the brake blocks the ejector is again brought into action and a vacuum created. In the event of the main pipe becoming severed accidentally, air is admitted and the brakes are automatically applied. This brake is also very rapid in action and is largely used.

Electricity as a motive power is now being much favoured by railway companies, the advantages claimed being that it enables a greater volume of traffic to be dealt with at a reduced cost of working. Several existing railways are electrifying their systems, a notable instance being the underground lines of London. In America electric railways have already reached a considerable mileage, and there is little doubt the development of this system of motive power is likely to be far reaching.

A Light Railway is a railway made under powers obtained from the Board of Trade and the Light Railway Act, the object being to develop country districts at present not provided with railways. Such lines are constructed as cheaply as possible, level crossings are allowed in lieu of bridges, and signalling is as simple as is consistent with safety.—A. W. S.

Railway Wheels. Although the wheels and axles used on railways vary in detail, the general types do not differ greatly. There is, however, a marked difference between the wheels of a roadway and a railway vehicle; *i.e.* in the case of the former the wheels revolve on the axle, whereas on the latter the wheel and axle revolve together. There are two general types of railway wheels in use in Great Britain, *viz.* the open body with spokes or arms now used chiefly for wagons, and the solid body or Mansell wheel fitted to carriages and vans. A wheel consists of the axle, terminating in journals (which accommodate the axle-box, brasses, springs, etc.), boss, body, tread, and tyre, the two latter together constituting the flange. The axles are made of a high class wrought iron or steel, capable of being bent double, when cold, without fracture; the boss may be of cast or wrought iron, and is shrunk on the axle; the body may be of wrought iron or solid

wood; the flange is of steel. When the body is of wrought iron the spokes or arms are fixed in the hub, and secured to the flange by shrinking and keying (fig. 1). In a Mansell wheel the solid

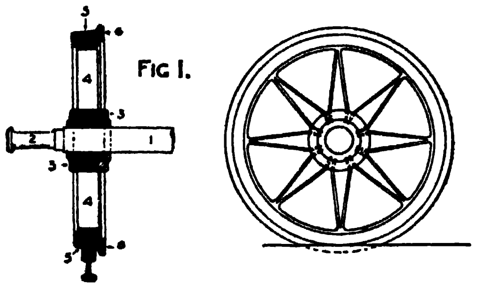


FIG 1.

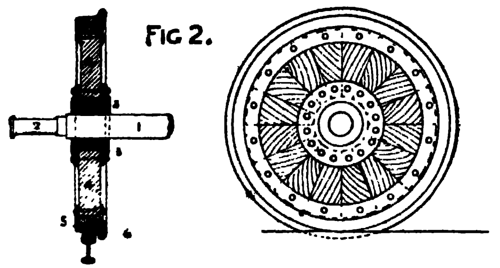


FIG 2.

1. Axle. 2. Journal. 3. Boss. 4. Body.
5. Tread. } Flange.
6. Tyre.

wooden body is bolted to the hub and flange, as shown in fig. 2. The advantages of a Mansell wheel are the reduction in resistance and a continuous support to the flange. In America and other countries a wheel made of cast iron is favoured. A system now largely adopted is the bogie truck, which consists of two or three pairs of Mansell wheels attached to a frame. The carriage rests on two such bogie trucks, one at each end, and is fixed by a pivot placed in the centre of each truck. This arrangement greatly reduces the rigidity of the wheel base, and enables the vehicle to travel round sharp curves with the minimum of friction.

Rain (*Meteorol.*) When clouds form over a region in which the air is nearly or quite saturated with moisture, the globules of water which form the cloud unite and descend through the stratum of moist air underneath, and fall as rain when the temperature is above freezing point. *See* CLOUDS *and* SALT.

——, **Geological Action of.** Rain water contains a small percentage of carbonic acid, which enables it to act chemically upon various rocks, especially upon limestone. But its chief function consists in washing away disintegrated materials, and thus exposing new surfaces to attack. Furthermore, rain contains a small percentage of the salt dust derived from sea spray, which is transferred from the air to the land. These salts may be carried by streams to arid regions, and there accumulate as the water evaporates.

Rain Band (*Meteorol.*) An absorption band in the solar spectrum due to the aqueous vapour in the earth's atmosphere. The intensity of this band increases as the aqueous vapour becomes more abundant.

Rainbow (*Meteorol., Phys.*) The prismatic arch of light formed by the reflection of light from the internal surface of drops of rain on which the sun is shining. The chief or PRIMARY BOW has a radius of 40° for the violet and 42° for the red light; hence the violet is inside, the red outside. The SECONDARY BOW is due to light which has been reflected twice; it is outside the primary bow, and the relative position of the colours is reversed. The radii are 51° for the red and 54° for the violet light. Bows due to three, four, etc., reflections are occasionally produced; they lie between the observer and the sun, but are obscured by the bright light. The fifth bow, however, is occasionally observed, as it lies in the same part of the sky as the primary and secondary bows. LUNAR BOWS, which are similar phenomena produced by the moon, are occasionally noticed under favourable conditions at full moon. Inside the primary or just outside the secondary bows there may sometimes be seen other bows; these are termed COMPLEMENTARY, SPURIOUS, or SUPERNUMERARY BOWS; they are due to INTERFERENCE (*q.v.*)

Rain Cloud (*Meteorol.*) A cloud or system of clouds from which rain is falling. This type of cloud is the Nimbus or Cumulo-cirro-stratus. *See* CLOUDS.

Rainfall (*Meteorol.*) The amount of rain falling in a given time is expressed by the depth to which it would cover a flat surface if the whole of the water remained upon it. "One inch of rain" is an amount which would cover the ground to a depth of one inch; this requires about 60,000 tons of water per square mile. *See also* METEOROLOGY.

Rain Gauge (*Meteorol.*) An instrument which in its simplest form consists of a funnel whose opening or mouth is of known area, and a collecting vessel, screened from wind and sun to prevent evaporation, placed beneath it. By measuring the total quantity of rain collected in a given time, it is easy to calculate the amount which has fallen on any area.

Rain Water (*Chem.*) *See* WATER.

Rain Water Pipe (*Build.*) The pipe that carries the water from the roof, gutters, etc.

Rain Water Separator, Roberts'. An apparatus which prevents the suspended matters—soot, decaying leaves, bird droppings—in rain water from passing into the storage tank. The separator is made of zinc upon an iron frame, the centre part being placed on a pivot. The first part of the rainfall passes through a waste pipe, and after a certain amount has fallen the separator cants over and passes the clear water into the storage tank.

Raised Beach (*Geol.*) Strictly speaking, the term "raised beach" ought to be restricted to deposits of sand and shingle which have been formed at the margin of a lake or on a seashore by the action of the waves, and have subsequently been elevated by terrestrial movements to a position in which, while the level character of the surface is still retained, the waves can no longer affect the deposit. But the term is also applied to a rocky shelf or ledge which has been sculptured by wave action, and has been elevated so as to be out of reach of the agent that shaped it.

Raised Oil. *See* RAISING.

Raised Panel (*Carp. and Join.*) A panel thicker in the centre than at the edges.

Raised Work (*Eng.*) Sheet metal work which has been shaped by hammering. This process is chiefly used in the production of ornamental work in copper, brass, etc.

Raising (*Leather Manufac.*) A process of raising or recovering the oil from the washings in the manufacture of chamois or oil leather. The wash waters are run into a large tub and heated with acid. The acid splits up the soap, and the oil is "raised" and floats on the surface: this oil is termed "RAISED OIL" or "SOD OIL" (*q.v.*)

—— (*Woollen Manufac.*) Applied to woollen cloths, and consists of drawing the fibre from the surface of the threads by means of teazles or card wire. Such cloths as beavers, meltons, pilots, blankets, etc., are raised

Raising Piece (*Carp.*) A timber laid on a wall or other support to carry a beam or beams.

Raising Plate (*Carp.*) A wall plate for carrying the heels of rafters. *See* ROOFS.

Rake (*Mining*). A Cornish term for a lode or vein.

——, **Raking.** (1) Slope or inclination. (2) A tool of the familiar pattern, used in many metallurgical and other operations.

Raking Bond (*Build.*) Diagonal or herring-bone bond.

Raking Cornice (*Architect.*) The cornice in a pediment (*q.v.*) bounding the sloping sides of the tympanum (*q.v.*)

Raking Flashing (*Build.*) The inclined flashing (*q.v.*) used on a roof against a stone wall.

Rallentando (*Music*). Gradually decreasing the pace.

Ram (*Eng.*) The piston of a hydraulic press (*q.v.*)

Ramie Fibre (*Botany*). A fibrous material which is now often used for many purposes in which cotton was formerly employed. *See* RHEA.

Ram Leather (*Eng.*) The cup leather of a press. *See* HYDRAULIC PRESS.

Rammer (*Foundry*). A cast iron head fixed to a handle; used for filling a moulding box and forcing the sand into close contact with the pattern.

Ramp (*Build.*) (1) A curve, concave on the upper surface; *e.g.* the upward bend of a handrail at a landing. (2) The curved or straight shoulder connecting the coping of a wall at different levels. (3) The coping of a stair or steps. (4) The difference of level in the abutments of a Rampant Arch (*q.v.*)

—— (*Eng.*) An inclined plane used in raising or lowering heavy weights through small distances.

Rampant (*Her.*) Lions and beasts when represented standing on the hind legs with one fore leg elevated are blazoned rampant. It is the natural position of an animal springing on its prey.

Rampant Arch (*Build.*) An arch with its springing higher on one abutment than the other.

Rampant Guardant (*Her.*) As rampant, but face turned to spectator.

Rampant Reguardant (*Her.*) As rampant, but head turned to look behind.

Random (*Typog.*) A sloping frame, generally used in making up type into pages.

Random Ranges (*Textile Manufac.*) Experimental ranges or pattern trials made with a view of acquiring styles from which ranges proper may be constructed.

Random Rubble (*Build.*) Masonry consisting of stones of various sizes and shapes which are not built in courses.

Range. (1) Compass, extent, scope. (2) A series of things standing in line. (3) The series of sounds of which the voice or a musical instrument is capable. (4) A kitchen grate with which is combined a cooking apparatus, etc.

—— (*Biol.*) (1) The geographical distribution of an animal or plant. (2) The geological period throughout which it has existed on the earth.

Ranging *or* **Setting Out** (*Surveying*). The location and marking on the ground of required points.

Ranging Rod (*Surveying*). A simple straight rod, coloured so as to be easily distinguishable, used for marking any required point.

Rank (*Music*). Used of pipes in an organ, and signifies a row of pipes belonging to a certain stop. The mixtures are of three, four, or five ranks. *See* MIXTURES.

Ranseur (*Arms*). A mediæval spear with accessory spikes at the base of the point.

Ranunculaceæ (*Botany*). An important natural order of Dicotyledons, chiefly found in the North Temperate Zone. Many garden and medicinal plants belong to the order, such as Aconitum, Actæa, Clematis, Ranunculus, Delphinium, Pæonia.

Raoult's Method (*Chem.*) A method of determining molecular weight by the lowering of the freezing point of a solution. The apparatus commonly employed is Beckmann's. It is described under FREEZING POINT (*q.v.*)

Rape Oil. This oil is substantially the same as colza oil, and is prepared by expressing the small black spherical seeds of the rape plant, *Brassica napus*, which is grown in most parts of Europe and in many places abroad. The oil is used for illuminating, in soapmaking, and for lubricating purposes. Sp. gr. at 18° C. 0·914 to 0·916.

Raphides (*Botany*). The term applied to the needlelike crystals of oxalate of lime, usually acicular in form, found in the tissues of many plants.

Rapidamente, Rapido (*Music*). With rapidity.

Rapier (*Arms*). A light, narrow, sharp pointed sword (a small sword), designed for thrusting, used from the sixteenth century onwards. Originally a long two edged sword, suited for cutting or thrusting.

Rapping (*Foundry*). Loosening a pattern from the sand by tapping or hammering. To prevent injury to the pattern, plates of metal termed RAPPING PLATES are let into the wood in convenient positions; these may be struck with suitable tools termed RAPPING BARS and RAPPING MALLETS.

Rasch (*Music*). Quick; comparative, *rascher*.

Raschette Furnace (*Met.*) A form of BLAST FURNACE (*see* FURNACES) with a wide hearth and a number of tuyères; it is used in smelting lead and copper in America.

Rasp (*Carp., etc.*) *See* FILES.

Raspberry (*Botany*). A well known fruit, *Rubus idæus* (order, *Rosaceæ*), consisting of an aggregate of drupes. Each small drupe has a similar structure to that of a cherry or plum.

Ratchet. A RATCHET WHEEL (*q.v.*)

Ratchet Bar (*Eng.*) A bar with teeth like those of a RATCHET WHEEL (*q.v.*)

Ratchet Brace (*Eng.*) A tool for drilling holes in confined situations: the drill is rotated by a ratchet actuated by the handle of the brace, and pressure is applied to the tool by means of a screw which works in a nut on the brace itself or in a separate frame or clamp; turning this screw causes the "feed" or motion of the drill in the direction of its own length.

Ratchet Drill (*Eng., etc.*) *See* RATCHET BRACE.

Ratchet Wheel (*Eng., etc.*) A wheel with teeth of peculiar shape, somewhat resembling those of a circular saw. These teeth engage with a PAWL, a piece of metal hinged at one end and coming in contact with the edge of the teeth at the other. The paul may serve the purpose of communicating motion to the wheel or of preventing it from turning backward (*i.e.* it allows motion in one direction only).

Ratching (*Cotton Spinning*). The excess speed traverse of a mule carriage over the roller delivery as it travels outwards. This has the effect of stretching and subjecting the twisted thread to a further draft, and produces a more even spun thread. Sometimes spoken of as "Carriage gain."

Rate of a Chronometer (*Astron.*) The amount it gains or loses during one day. Rate is reckoned positive when the clock loses.

Rate of Denudation (*Geol.*) *See* DENUDATION, RATE OF.

Ratio (*Math.*) The relation between two magnitudes or quantities of the same kind; it is expressed by stating what multiple, part, or parts, one quantity is of the other. In mathematical symbols the ratio of A to B may be written A : B or $\frac{A}{B}$

Rational Formula (*Chem.*) Is the same as constitutional formula. *See* CHEMICAL FORMULA.

Ratio of Expansion (*Eng.*) The relation of the final volume to the initial volume of a gas which is allowed to expand. The term is especially applied in engineering to the expansion of steam in the cylinder of an engine.

Ratio of Specific Heats (*Phys.*) *See* SPECIFIC HEATS OF GASES.

Rat Trap Pedals (*Cycles*). Pedals in which the foot rests on notched steel bars instead of on bars covered with rubber. Lighter than the latter form, but not so free from vibration.

Raw. A term applied to various substances to denote that they are in a natural, unrefined, unmanufactured, undiluted, or undressed condition; *e.g.* raw hide = untanned hide; raw silk, silk simply reeled from the cocoon.

Raw Hide. Leather which has not been tanned. It is sometimes used for thongs and for driving belts.

Raw Linseed Oil. Oil that has not been boiled, so called to distinguish it from boiled linseed oil. *See* OILS.

Ray (*Music*). Second degree of scale in "Movab'e Doh" system.

—— (*Phys.*) The line along which the disturbance produced in any form of wave motion travels. Thus a ray of light may be regarded either as a line along which light travels, or as a normal to the wave front (*q.v.*)

Rayonné (*Her.*) *See* RADIANT.

Rays (*Her.*) The sun as a charge is sometimes represented with rays; they are alternately straight and wavy, and sixteen in number.

Rb (*Chem.*) The symbol for RUBIDIUM (*q.v.*)

Re (*Music*). The sol-fa syllable for D.

Reactance (*Elect.*) That part of the impedance (*q.v.*) of a circuit which is due to its self induction and capacity. In most cases in practice the effect of capacity can be neglected, and the reactance is $2\pi nL$, where L is the self induction and n is the frequency. *Cf.* IMPEDANCE.

Reactance Coil (*Elect. Eng.*) A CHOKING COIL (*q.v.*)

Reaction (*Chem.*) Chemical action occurring between two or more substances.

—— (*Mech.*) A general term for a force which is acting in opposition to another force or system of forces.

Reader (*Typog.*) A person whose province is to correct errors of the compositor in setting type, revise the various proofs, and be responsible for the accuracy of the forme before it is finally printed off. His duties commence with the first proof or impression, which is "run through" with the copy by its side, and all literals and other obvious errors marked by means of special signs. *See* PROOF CORRECTIONS. The copy is then given to a boy or girl, usually called a copyholder, who reads it aloud while the reader verifies the proof, paying special regard to orthography, punctuation, division and compounding of words, use of capitals, and the general "style" of the house, etc. When all the necessary marks are made, the proof is handed to the compositor, who corrects it and pulls a "revise." The reader compares this with the first proof to see that all his marks have been carefully followed, in which case the type is made up into pages and imposed, etc. A proof in sheet form is pulled and folded, but not cut. It is then the reader's duty to read the headings of the pages, check the size, style, and register of the make up, and verify the folios or pagination, signatures, and connections of the pages. When these points have had due attention by the compositor, the author's proof is pulled; and after the reader has indicated upon it any query he deems necessary to raise, it is submitted for approval. On its return, this proof is carefully and critically perused by the press reader as a whole. In the event of the alterations being considerable, involving disturbance of lines or paragraphs, the proof is first given to the compositor; and after the author's corrections are made, a further proof or press revise is pulled, upon which the final marks are made, and the work "passed for press."

Readers' Marks (*Typog.*) *See* PROOF CORRECTIONS.

Reading Beds (*Geol.*) A series of clays, loam, and sands, with some pebble beds, formed under fresh water, estuarine, and marine conditions during the Lower Eocene Period in the London Basin. The estuarine and marine type is found to the east of London, and the fresh water type mostly to the south and the west.

Reading Microscope *or* **Telescope** (*Phys., etc.*) A microscope or telescope used for reading the indications of a finely divided scale or other instru-

ment, or for measuring small distances. Reading microscopes are usually mounted so that the axis of the instrument can be moved parallel to itself through small distances, which can be accurately read off on a scale attached to the frame of the instrument. In many cases a fine adjustment is provided by means of a screw with a graduated head.

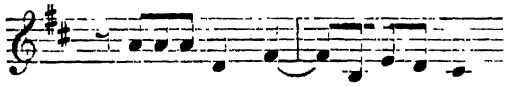
Reading Off (*Lace Manufac.*) Converting the lines that represent threads upon the draft into figures for the use of the Jacquard card puncher. *See* DRAFTING.

Reagent (*Chem.*) Any chemical substance (element or compound) used to bring about a chemical change. Thus in qualitative analysis (*q.v.*) the chemicals used to precipitate the various groups of metals are called group reagents. The word is, in fact, more commonly used to denote chemicals used in testing than any others. For example, we have the alkaloid reagents (*q.v.*), Nessler's reagent (*q.v.*) Phenylhydrazine is a reagent for aldehydes and ketones.

Real Fugue (*Music*). A fugue having the intervals of the answer strictly repeated in the fifth above (or fourth below), *e.g.*:

Subject. J. S. BACH.

Real Answer.



Realgar (*Min.*) One of the sulphides of Arsenic; AsS. Arsenic = 70·1, sulphur = 29·9 per cent. Monosymmetric, usually massive. Colour, orange red; lustre, resinous. It is usually associated with the other sulphide Orpiment. From Northern Hungary, Transylvania, Bohemia, Asia Minor, etc.

Real Image (*Light.*) *See* IMAGE *and* CONJUGATE FOCI.

Realism (*Art, etc.*) Rendering or reproducing precise details of a subject or scene. In recent years the term has been employed to indicate that the details are of an unpleasant character. Opposed to Idealism.

Ream (*Paper Trade*). A certain quantity of paper, generally 480 sheets or 20 quires, but varying slightly according to the purpose for which it is intended; *e.g.* a printers' ream consists of 21½ quires (516 sheets), to allow for waste in printing.

Reamer (*Eng., etc.*) A tool used for enlarging or truing a hole already drilled. A common form consists of a short shaft with longitudinal cutting ridges.

Rear Vault (*Architect.*) The vaulted surface on the interior of a window head in a thick wall.

Rebate (*Carp., etc.*) A synonym for RABBET (*q.v.*)

Rebated (*Her.*) Broken off.

Rebec (*Archæol.*) A lute-shaped musical instrument of mediæval times, with one, two, or three strings, played by a bow; the prototype of the violin.

Rebus (*Her.*) An allusive device. Charges frequently occur in heraldry in which the bearer's name is suggested. For instance, Dearing blazons a deer and a ring; Ashton, an ash tree issuing from a tun or cask; Abbot Ramryge adopted for supporters two rams wearing collars with the letters "Ryge."

Recalescence (*Phys.*) If a piece of iron wire which has been heated to a red heat be allowed to cool in a dark room, it cools down, losing its glowing appearance, and then suddenly glows out again, when its temperature has fallen to a certain value. This phenomenon is termed RECALESCENCE, and the temperature at which it occurs the TEMPERATURE OF RECALESCENCE.

Receiver (*Eng., etc.*) (1) A general term for a receptacle, place of storage, etc. (2) In the foundry, a tank into which metal for large castings is run from the cupola, and from which it is run into the moulds. (3) In telegraph and telephone practice, etc., it signifies the instrument by which a message is received.

Recess (*Build.*) The inside of a REVEAL (*q.v.*)

Recessing Machine (*Join.*) A machine used for sinking (*q.v.*), housing (*q.v.*), and for cutting out recessed and shaped work generally.

Reciprocal. The reciprocal of a quantity is equal to unity divided by the quantity.

Reciprocal Figure. *See* GRAPHIC STATICS.

Reciprocating. Applied in engineering, etc., to mechanism of which the parts move backwards and forwards alternately, as is the case in ordinary steam engines.

Recitando, Recitante (*Music*). In a reciting manner.

Recitative (*Music*). A composition without regular rhythm, being of a declamatory character. Recitatives are of two kinds: (1) *Recitativo secco*, recitative supported by occasional chords only, in which the performance is in free time; and (2) *recitativo con accompagnamento* or *stromentato*, accompanied recitative, in which the performance is in comparatively strict time. "Comfort ye My people" (Handel's *Messiah*) is a good example of both kinds of recitative.

Recorder. An instrument which produces a record of its indications in some form of written or printed symbols. *See also* RECORDING AMMETER, *etc.*

Recording Ammeter, Voltmeter, etc. (*Elect.*) An instrument by which the value of a current, voltage, etc., is continuously recorded on a drum or card.

Recording Drum (*Phys., etc.*) A revolving drum covered with paper or some other suitable surface, on which the indications of an instrument are recorded by means of a line whose distance from a fixed zero line represents the displacement of the indicating portion of the instrument, and therefore the value at any given instant of some quantity which it is desired to record. The drum is rotated at a known uniform rate by clockwork or other means.

Recovered Sulphur (*Chem.*) *See* CHANCE'S PROCESS.

Rectangle. A plane, four-sided figure, whose angles are all right angles.

Rectangular Components. *See* RESOLUTION OF FORCES.

Recte et Retro, Per (*Music*). *See* PER RECTE ET RETRO.

Rectification (*Chem.*) Literally a second distillation. To rectify a liquid means to redistil it. Rectified spirit is alcohol which has been at least twice distilled; it has a variable strength of from over 80 to about 91 per cent. by weight of alcohol.

—— (*Elect.*) The conversion of an alternating current into a continuous or uni-directional current.

Rectified Spirit. *See* ALCOHOL.

Rectifier (*Elect. Eng.*) A machine or piece of apparatus for converting an alternating current into a uni-directional current. A rectifier may be (1) a mechanical device of the nature of a COMMUTATOR (*q.v.*), or (2) a ROTARY CONVERTER (*q.v.*), or (3) it may depend on some electrolytic action, being then termed a CHEMICAL *or* ELECTROLYTIC RECTIFIER. Electrodes formed by a pair of plates of aluminium, dipping into a suitable solution (*e.g.* ammonium phosphate) are connected to the alternating current supply, when it is found that the current will pass through the cell in one direction only. The current may be used for actuating an induction coil or even for charging accumulators.

Rectilinear (*Architect.*) *See* CURVILINEAR *and* PERPENDICULAR.

Recto (*Typog.*) The right hand page of a printed work. *Cf.* VERSO.

Rectum (*Zoology*). The terminal portion of the alimentary canal communicating with the exterior by the anus.

Red Builders. *See* BRICKS.

Red Crag (*Geol.*) A member of the Older Pleiocene Rocks which is typically developed in East Anglia. It contains a large number of species and individuals of fossil shells in a good state of preservation. The formation, as a whole, presents a ruddy aspect, which is due to the presence of iron oxide, probably arising from the alteration of Glauconite.

Reddle (*Eng.*) A mixture of red lead and oil, used to show which parts of two surfaces are in contact when brought together as closely as possible. The mixture is rubbed on one surface, and it marks the points of contact when the second surface is pressed or rubbed against the first. *See* SURFACING.

—— (*Min.*) An earthy variety of Hæmatite (*q.v.*), used as a pigment and as a polishing agent. *See* HÆMATITE.

Red Fog (*Photo.*) A reddish haze on a negative. Red fog is very apt to make its appearance during intensifying with silver nitrate if the solution is not kept in motion, or if too little acid is present as a restrainer.

Red Heat. The temperature at which a body emits a red glow. It varies within certain limits, but may be given as 700° to 800° C.

Red Lead (*Chem.*) *See* LEAD COMPOUNDS.

—— *or* **Minium** (*Dec.*) An oxide of lead having an approximate formula of Pb_3O_4 and a specific gravity of about 8·62. It is of a bright orange or scarlet colour, and is made from metallic lead, which is heated in an open furnace, a current of air being passed over the molten lead, which absorbs oxygen, and is converted into litharge. This is ground to a fine powder, and heated in the furnace a second time, when it absorbs more oxygen, and becomes (when cool) a bright red colour. The principal advantages of red lead have been thus summarised: It is inexpensive; it forms a strong protective covering to the iron or woodwork to which it is applied; it is very durable, resisting alike the action of frost, damp, and heat; it is remarkably adhesive; it mixes well with linseed oil; it has a powerful drying action on oil, and hence dries quickly; it possesses good covering properties, and it may be mixed with, or applied over, any of the other pigments without affecting them or being affected itself, with the exception of ultramarine, cadium yellow, and those pigments which contain sulphur. The disadvantages are stated by way of contrast as follows: Red lead is quite inadmissible as a water paint; it is influenced by sulphuretted hydrogen, and turns quite black under its influence; it sets quickly; it is somewhat difficult to work. The bright orange colour of red lead is sometimes objectionable. This may be avoided by mixing lampblack in a proportion not exceeding 1 oz. to the pound. When used as paint it must be mixed fresh every day, or even several times a day, as it sets so quickly. About a gallon of linseed oil is required to grind 100 lb. of red lead. For painting articles which are to be subjected to a good deal of rough usage and hard wear, such as agricultural implements, carts, waggons, etc., red lead is generally used. It is also employed to considerable extent for a priming coat (*q.v.*) on woodwork, being mixed with white lead. It should not, however, be used under white work. The fact that it hardens quickly causes it to be used largely in various cements. *See also* LEAD COMPOUNDS.

Red Oils (*Chem. Tech.*) Crude oleic acid, obtained in the manufacture of stearine.

Red Oxide of Copper (*Min.*) *See* CUPRITE.

Red Oxide of Zinc (*Min.*) *See* ZINCITE.

Red Phosphorus (*Chem.*) *See* PHOSPHORUS.

Red Precipitate (*Chem.*) A common name for the red form of mercuric oxide. *See* MERCURY COMPOUNDS.

Redruthite (*Min.*) *See* CHALCOCITE.

—— (*Mining*). *See* COPPER GLANCE.

Red Sandstones. *See* BUILDING STONES.

Redshort (*Met.*) A term applied to iron or steel which cannot readily be forged or rolled at or above red heat. It is caused by the presence of 0·2 per cent. of sulphur in wrought iron or steel; 0·5 per cent. of copper in the case of iron; 0·2 per cent. of antimony in either iron or steel. Pig iron containing 0·3 per cent. of sulphur invariably yields redshort steel by the Bessemer or Siemens processes. In steel 0·5 per cent. of silicon causes redshortness. *Compare* COLDSHORT.

Red Silver Ores (*Min.*) Under this term are included PYRARGYRITE *and* PROUSTITE (*q.v.*)

Reduced Work (*Build.*) A wall the standard thickness of one and a half bricks. All walls are reduced to this thickness for the purpose of measurement. *See* ROD.

Reducing Agents (*Chem.*) *See* REDUCTION.

Reducing Furnace (*Met.*) A furnace in which ores of metals are reduced, *i.e.* the combined oxygen is removed. A blast furnace is therefore a reducing furnace.

Reducing Mixtures (*Chem.*) A mixture of two or more substances, employed to effect Reduction (*q.v.*) A substance capable of acting as a flux (*q.v.*) is often included in the mixture.

Reducing Pipe, Joint, *or* Socket. A pipe or joint, etc., used to connect together two pieces of piping of different diameters.

Reduction (*Chem.*) This process is the converse of oxidation (*q.v.*) It may consist in any one of the following operations: (1) removal of oxygen from a compound; (2) addition of hydrogen to a compound; (3) changing an "-ic" salt to an "-ous" salt; (4) replacing another element by hydrogen. Examples: (1) when carbon dioxide is passed over red-hot carbon it loses an atom of oxygen, $CO_2 + C = 2CO$. Many metallic oxides when heated with carbon or in a stream of hydrogen or carbon monoxide give up oxygen, and are reduced either to the metal or to a lower oxide; thus ferric oxide, cupric oxide, zinc oxide, stannic oxide, lead oxide all give the metal; but the oxides of manganese are only reduced as far as manganous oxide, MnO. As an organic example the removal of oxygen from azoxybenzene (*q.v.*) by distillation with iron filings may be given. (2) This may occur with or without resolution of the original compound into simpler ones. Aldehydes unite with hydrogen directly to form alcohols:

$$R - C \begin{matrix} \diagup H \\ \diagdown O \end{matrix} + H = R - C \begin{matrix} \diagup H \\ - H \\ \diagdown OH \end{matrix}$$

ketones (*q.v.*) to form secondary alcohols. Aromatic hydrocarbons and their derivatives are frequently reduced by sodium and alcohol or by hydriodic acid to hydro-aromatic compounds; for examples *see under* NAPHTHYLAMINES *and* PHTHALIC ACID. Hydrazines are reduced by tin and hydrochloric acid to amines and ammonia; *e.g.*

$$\underset{\text{Phenylhydrazine.}}{C_6H_5 . HN . NH_2} + 2H = \underset{\text{Aniline.}}{C_6H_5NH_2} + NH_3.$$

(3) This change can be effected in some cases in the dry way, as when hydrogen is passed over heated chromic or ferric chlorides. It is commonly effected in solution when the reaction is an ionic reaction and the actual change consists in the removal from a positive ion of one or more quantities of electricity each equal to that carried by the hydrogen ion; *e.g.* the reduction of ferric chloride solution by zinc and dilute sulphuric acid may be represented thus:

$$\underset{\text{Metal.}}{Zn} + 2\overset{+}{H} + \overset{=}{SO_4} = \underset{\text{Ion.}}{\overset{++}{Zn}} + \overset{=}{SO_4} + \underset{\text{Free hydrogen.}}{H_2}$$

$$2\overset{+++}{Fe} + 6\overset{-}{Cl} + H_2 = 2\overset{++}{Fe} + \underset{\text{Ion.}}{2\overset{+}{H}} + 6\overset{-}{Cl}$$

(4) Common examples of this kind of reaction are the replacement of chlorine or oxygen by hydrogen; *e.g.* methyl iodide is reduced by the zinc copper couple in presence of alcohol to methane; trichloracetic acid in aqueous solution is reduced to acetic acid by potassium amalgam; succinimide,

$$\left.\begin{matrix} CH_2 - CO \\ | \\ CH_2 - CO \end{matrix}\right> NH$$

can be reduced to 2-pyrrolidine,

$$\left.\begin{matrix} CH_2 - CO \\ | \\ CH_2 - CH_2 \end{matrix}\right> NH$$

or to pyrrolidine—

$$\left.\begin{matrix} CH_2 - CH_2 \\ | \\ CH_2 - CH_2 \end{matrix}\right> NH$$

See PYRROLE. Reagents which effect reductions are called reducing agents; they are, of course, substances which can themselves be somewhat readily oxidised. Examples of reducing agents are hydrogen, carbon, sulphurous acid, sulphuretted hydrogen, stannous chloride, hydriodic acid, sodium stannite, zinc dust, aldehydes.

Reduction Factor (*Elect.*) If a unit current in a galvanometer produce a magnetic field of strength G, and H be the strength of the controlling field (due to the earth, control magnet, etc.) at right angles to this, the ratio $\frac{H}{G} = k$ is termed the Reduction Factor of the galvanometer. If the deflection δ be proportional to the current C, then $C = k\delta$; in the case of a tangent galvanometer, $C = k \tan \delta$. *See also* GALVANOMETERS.

Reduction of Area. When a piece of metal is drawn out in a testing machine the area of its cross section becomes reduced; the amount of reduction which occurs before the specimen breaks is a good test of the quality of the metal.

Redundant (*Music*). A term applied by some writers to augmented intervals.

Redwood. *See* WOODS.

Reed (*Carp. and Join.*) A bead without a quirk.

—— (*Music*). A thin piece of cane or metal which vibrates and produces a musical sound when a column of air passes it. Reeds are of two kinds—free reed, as in the harmonium (*q.v.*, p. 442), and the striking reed, as in the organ (*q.v.*, p. 441). *See also* REED INSTRUMENTS, p. 431.

—— (*Weaving*). A comb-like instrument with splits or dents of varying gauge. It is fixed in the loom sley, and serves three useful purposes, *viz.* (1) it maintains the warp threads in corresponding positions throughout weaving, and fixes the gauge or set of the cloth; (2) assists in the beating up; (3) acts as a guide when the shuttle is crossing. Also used in the preparatory processes for regulating the width of warp threads. Reeds were first made of metal by John Kay, the inventor of the fly shuttle. *See* LOOM.

Reed Marks, Reedy (*Weaving*). Defective streakiness warpways of the cloth, due to the threads rolling in the splits of the reed, particularly in mat weaves. They may also occur in the direction of the weft, due to the reed cutting the picks of weft. The reverse of "cover" (*q.v.*)

Reef (*Mining*). (1) A lode or vein; (2) the outcrop of a vein.

Reel (*Textile Manufac.*) A skeleton cylinder on which yarn can be wound in 1 or $1\frac{1}{2}$ yard lengths, for the purpose of ascertaining its counts (*q.v.*)

Reeler (*Paper Manufac.*) Apparatus for working up the dry paper from the machine into a reel, for use on a Rotary printing press. *See* TYPOGRAPHY.

Reeling (*Cotton Manufac.*) Winding the thread by means of a reel from a ring bobbin or cop into a standard length, such as a "lea" or "hank," so as to be more convenient for dyeing purposes. Two forms of reeling are employed, *viz.* (*a*) straight reeling, (*b*) cross reeling.

—— (*Textile Manufac.*) The operation of reeling and hanking the yarns. Woollen yarns are hanked on the 1 yard reel, worsted on both 1 yard and 1½ yard, and cotton on the 1½ yard.

Reel of Paper (*Paper Trade*). The form in which paper is supplied for use on Rotary machines. It is printed in continuous lengths.

Refectory (*Architect.*) A hall in which meals were formerly taken.

Reference Marks (*Typog.*) *See* NOTES.

Refined Iron (*Met.*) White cast iron which has been partially deprived of its carbon previous to the process of puddling (*q.v.*) The process termed REFINING (*q.v.*) is dispensed with when the pig iron is converted into wrought iron by the process of PIG BOILING or WET PUDDLING (*q.v.*)

Refiner (*Paper Manufac.*) A conical shaped apparatus similar to the "perfecting engine" used for beating pulp.

Refinery. A place in which the processes of Refining (*q.v.*) are carried on.

Refining. A term applied in a very wide manner to various purifying processes, *e.g.* the final stages in the manufacture of spirits, sugar, metals, etc.

Refining of Iron (*Met.*) Pig iron is heated in a furnace resembling a cupola, or small blast furnace, but with a number of tuyères which point downwards towards the hearth, so as to cause an abundant supply of air to play on the molten iron. A great deal of the carbon and most of the silicon are oxidised and removed from the iron, which is then run into moulds, suddenly cooled by water, and broken up, when it is ready for Puddling (*q.v.*) *See also* IRON.

Reflecting Galvanometer (*Elect.*) *See* GALVANOMETERS.

Reflecting Telescope (*Astron.*) A telescope in which a mirror is employed for obtaining the primary image. They take several forms, the chief of which is known as a Newtonian.

Reflection (*Phys.*) If any disturbance, whether of the nature of wave motion or of actual motion of translation of matter, impinge upon a surface which changes the direction of motion of the disturbance, and sends it back through the medium on the same side of the surface as that on which it was originally travelling, the disturbance is said to be REFLECTED. The surface which produces the change in direction is said to be a REFLECTING SURFACE.

Reflection Grating (*Phys.*) *See* DIFFRACTION GRATING.

Refracting Telescope (*Astron.*) A telescope in which a lens is employed for obtaining the primary image.

Refraction (*Phys.*) If a disturbance pass from one medium to another, the direction of propagation generally undergoes a sudden change; the ray (*q.v.*) is turned through an angle at the point where it meets the surface of separation of the two media. This bending, or change of direction, is termed REFRACTION. The same term is also applied to other phenomena having a certain resemblance to the foregoing, *e.g.* the change in direction of the lines of flow of an electric current when it passes from any conducting medium to another of different conductivity, or of the lines of electric or magnetic force in passing from one medium to another of different Specific Inductive Capacity (*q.v.*) or different Permeability (*q.v.*) respectively.

Refractive Index (*Phys.*) *See* INDEX OF REFRACTION.

Refractometer (*Phys.*) An instrument for the measurement of the refractive index (*q.v.*) The INTERFERENCE REFRACTOMETER depends upon the interference of two beams of light, derived from the same original source, when a transparent medium is interposed in the path of one of the beams.

Refractory (*Met.*) Applied to infusible substances such as fireclay, lime, etc., which are used as crucibles and furnace linings.

Refrigeration. Cooling to a low temperature. The process is extensively applied to articles of food (meat, etc.) in order to prevent decomposition during transit.

Refrigerator. (1) A cold chamber for storage of perishable foods, etc. (2) A machine for the artificial production of cold. On a large scale this result is produced by allowing a compressed gas to expand rapidly in coils surrounded by brine or air. Heat is absorbed and refrigeration effected. The compression of the gas is effected by pumps driven by power, and the heat produced by the compression is carried off by means of water jackets through which a continuous stream of water circulates. Ammonia gas or carbon dioxide is found to be very convenient for this use; after expansion, it is again compressed, and used over and over again with little or no loss of gas.

Refuse. (*a*) Street. By Sec. 29 of the Public Health (London) Act, 1891, it is the duty of the Sanitary Authority to collect and remove street refuse, defined by Sec. 141 to consist of dust, dirt, rubbish, mud, road scrapings, ice, snow, and filth. (*b*) House. Sec. 30 requires the removal by the Sanitary Authority, at proper periods, of all house refuse, defined as ashes, cinders, breeze, rubbish, night soil, and filth, but does not include trade refuse. (*c*) Trade Refuse, that is, the refuse of any trade, manufacture, or business, or of any building materials, must be removed by the Sanitary Authority at the request of the owner or occupier of the premises, and on payment of a reasonable sum for such removal (Sec. 34). (*d*) Offensive Refuse. It is not the duty of the Sanitary Authority to remove such refuse, but the Sanitary Inspector shall serve a notice on the owner or occupier of the premises where it exists, requiring its removal. If within forty-eight hours the notice is not complied with, the Sanitary Authority may remove and sell or otherwise dispose of it (Sec. 35).

Regal, Regals (*Archæol.*) A miniature reed-pipe organ of the sixteenth and seventeenth centuries. It was supported by the player, the bellows being manipulated by one hand and the manual played by the other.

Regelation (*Heat*). If ice be subjected to pressure, the freezing point is lowered, and some of the ice melts. On the withdrawal of the pressure, freezing occurs again; to the latter process the term Regelation is applied.

Regenerative Furnace. A furnace in which hot waste gases are utilised to heat the incoming air, or, in the case of gaseous fuel, the mixture of air and combustible gases. They first pass through a chamber filled with open brickwork, to which a large portion of the heat is given up; when the chamber is sufficiently heated, the air, or mixture of air and combustible gases intended to supply the furnace, is caused to pass through it, while the waste gases flow through a second brickwork chamber or REGENERATOR. Thus the air and gas entering the Regenerative Furnace are already at a high temperature, and economy of working results.

Regenerator (*Met., etc.*) The chamber of a Regenerative Furnace (*q.v.*) It is filled with brickwork arranged as chequer work, *i.e.* with spaces between the bricks, so as to present a large amount of surface to the gases.

Register (*Typog.*) Accurate adjustment in printing the second side of a page, or the "re-iteration" of a sheet, as it is sometimes termed. Perfect registration is necessary in order that the margin of the pages may be exactly even when the sheets are folded. In colour printing, the absolute agreement of two formes which is necessary when one colour is imposed on another.

Register Sheet (*Typog.*) The sheet or sheets of paper used in making register, usually of a common quality when the paper on which the work is to be printed is expensive.

Register Stove (*Build.*) A stove with an iron flap, the REGISTER, placed over the opening of the flue, which it serves to close.

Reglet (*Architect.*) A flat, narrow moulding used to separate larger mouldings, or to form frets, etc.

—— (*Typog.*) A kind of furniture (*q.v.*) made of wood, and of equal thickness all its length. It comprises all sizes up to "narrow" or three line pica.

Reguardant (*Her.*) Looking back. *See* LION REGUARDANT.

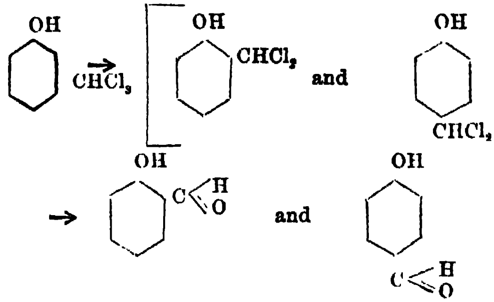
Regulator Valve (*Eng.*) A valve, controlled by the driver, which regulates the supply of steam to the cylinders of a locomotive.

Regulus (*Met.*) A mass of partly smelted ore or partly purified metal.

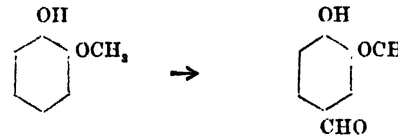
Reheating (*Met.*) The process of heating steel ingots in the mill furnace before rolling. It is often avoided by the use of SOAKING PITS (*q.v.*)

Reichardite (*Geol.*) A mineral found in the Carnalite region of Stassfurt. Composition: $MgSO_4$, 48·78 per cent.; H_2O, 51·22 per cent.

Reimer's Reaction (*Chem.*) A general reaction for the introduction of the aldehyde group into certain classes of aromatic compounds, especially phenols. For example, when phenol, chloroform, and an aqueous solution of caustic soda are boiled together under a reflux condenser a mixture of ortho- and para-hydroxybenzaldehydes is obtained, the former of which is volatile in steam—

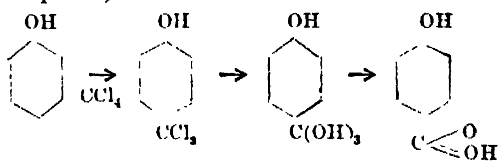


Other phenols can be used in place of ordinary phenol; for instance, if guaiacol is used, vanillin can be obtained.



Guaiacol.

Quite analogous is the formation of parahydroxybenzoic acid (with a little of the ortho-compound) by boiling phenol with carbon tetrachloride and alcoholic potash).



Reins (*Eng.*) A term sometimes applied to the handles of a blacksmith's tongs.

Reiteration (*Typog.*) The term applied to the "second" side of a sheet that has to be printed.

Relative Humidity (*Meteorol.*) *See* FRACTION OF SATURATION.

Relative Minor (*Music*). A key having the same signature as the relative major, but whose tonic or keynote is a minor third lower, *e.g.* A major, F♯ minor.

Relay (*Elect.*) A device consisting of an electromagnet through which a feeble current passes, causing the magnet to actuate a switch or contact maker by which another (and usually more powerful) current is turned on. The latter current, which is supplied by a local battery, acts on any required apparatus, *e.g.* a telegraphic receiving instrument.

Release (*Eng.*) The opening of the exhaust port of an engine cylinder to allow the escape of the steam or other gas at the end of the stroke.

Relief (*Art*). (1) In painting, the apparent projection obtained by modelling, or the gradation of tones or tints. (2) In Sculpture, the projection of figures beyond the ground or plane on which they are formed, *e.g.* alto-relievo, basso-relievo, mezzo-relievo (*q.v.*) (3) In architecture, the projection of mouldings and systems of ornament from the surface of a wall or façade.

Relief Printing (*Typog.*) A term used to distinguish letterpress from lithographic or plate printing.

Relieving Arch (*Build.*) *See* DISCHARGING ARCH.

Religioso (*Music*). In a devotional manner.

Reliquary. A depository or casket in which relics are preserved; a shrine.

Reluctance (*Elect.*) *See* MAGNETIC RELUCTANCE *and* MAGNETIC CIRCUIT.

Remanence (*Elect.*) The property possessed by a magnetic body (*e.g.* iron) of retaining a certain amount of magnetism after the original magnetising influence has ceased to act.

Removes (*Typog.*) A term used to express the gradations between type of different sizes.

Renaissance (*Art, etc.*) The period of transition from mediæval to modern times. In Europe this occurred between the beginning of the fifteenth and the end of the eighteenth century.

Renaissance Architecture. The revival of the use of classic forms which was one of the results of an intellectual movement beginning in Italy during the thirteenth century is known as the Renaissance. Even in Italy, however, it was not until the fifteenth century that Renaissance art asserted itself. The decline of the Renaissance in Italy began with the Baroque period, 1550—1600 A.D., and the Italian Renaissance ended with the Rococo style, a vulgar and debased architecture which obtained during the seventeenth century. English architecture began to show signs of the Renaissance in the Tudor period. The Tudor style obtained during the first half of the sixteenth century, and can be looked upon as a period of transition. In the Elizabethan period (1558 - 1603) the pointed arch is no longer used, and the orders are introduced as ornamental features. In the Jacobean style (1603—1625) classic details are more in evidence. Inigo Jones and Sir Christopher Wren were responsible for the principal buildings which were erected during the period in which the classic style—for which Gothic architecture made way at the close of the Jacobean period—obtained.

Render (*Chem. Tech.*) To extract and refine the fat, etc., from animal tissues by heat.

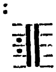
Rendering (*Plastering*). The first coat of plaster laid on a brick wall.

Rennet. A preparation of the mucous membrane of the stomach of a calf: used to produce coagulation of milk in making cheese, etc.

Rep (*Silk Manufac.*) A corded silk fabric showing a bold rib. Made with a binder warp in addition to the ground and with two shuttles, one carrying a coarse round thread of worsted or cotton, the other a fine thread or divider. If made face upwards the whole of the ground warp is raised for coarse shoot, 1st pick, and the whole of the binder cane for divider, 2nd pick.

—— (*Textile Manufac.*) A worsted, cotton, or silk fabric in which there are lines formed across the fabric, and in which only the warp shows on the face.

Repeat (*Music*). This is indicated by dots placed at a double bar:

 or 

and signifies that the section on the side of the double bar on which the dots occur is to be played twice. In the performance of the minuet or scherzo it is customary to omit the repeats in the Da Capo (*q.v.*) after the Trio.

Replacing Switch (*Eng.*) A device with an inclined plane by means of which derailed cars are placed upon the rails again.

Replenisher (*Elect.*) A small electrostatic machine for charging the needle of an electrometer.

Replica (*Art*). A facsimile of a work executed by the artist who produced the original. *Cf.* COPY.

—— (*Music*). Repeat. *Senza replica,* without repeats. *See* REPEAT.

Repose (*Art*). The term is applied to a work of art the details of which are well balanced and in harmony, no one feature unduly attracting the attention of the observer.

——, **Angle of** (*Phys., etc.*) The maximum angle at which any surface may be inclined without causing a body which rests on the surface to commence to slide down is termed the Angle of Repose. The term is commonly applied in practice to the maximum angle of inclination of the sides of a heap of loose material (*e.g.* earth, sand, etc.)

Repoussé. A style of decoration effected on metal work by beating the metal on one side with a hammer until a rough image of some desired figure or design is produced, which is then chased (*q.v.*)

Representative Fraction. *See* SCALE DRAWING.

Reredos (*Architect.*) The screen or wall panelling behind an altar in a church.

Reseau (*Astron.*) A network of lines forming small squares impressed on a glass plate. Used extensively in photographic star charting.

Reserve of Buoyancy (*Phys., etc.*) When a body floats in a liquid, and is only partially immersed, it is said to have a Reserve of Buoyancy. Further immersion can only be effected by the application of additional force (acting downward), and this force is opposed by an increased upward force due to the extra displacement of liquid.

Reservoirs (*Civil Eng.*) For the storage of water are made by excavation or embankment, the floor and sides being lined with concrete or well puddled clay. Service reservoirs should be covered and ventilated, and the water from the supply reservoir passed through filter beds of sand before entering the service reservoir for distribution. They should be placed on as high ground as possible to give a sufficient pressure of water, so that the supply may be assured by gravitation; otherwise the water must be raised by pumping.

Residual Charge (*Elect.*) A small charge remaining in a Leyden Jar or other condenser after it has been discharged.

Residual Gases. The gaseous products of combustion, together with any unburnt and incombustible gases, which remain in a gas engine cylinder or the bore of a gun, etc., after explosion.

Residual Magnetism (*Elect.*) The magnetism which is retained by iron, etc., after the magnetising force has ceased to act on it.

Resilience (*Phys.*) In general language the reaction of a body against a force producing distortion: in scientific terminology, the work expended in producing a given strain. This work is stored up in the body and can be recovered if the stress has not been increased beyond the elastic limit. The term Resilience is frequently restricted to the maximum amount of work which can be stored up in a strained body without exceeding the elastic limit.

Resilience (*Eng.*) If p be the stress when the elastic limit (*q.v.*) is reached, E the coefficient of elasticity, and V the volume of the body, then the Resilience $= \frac{1}{2}\frac{p^2}{E}V$. The quantity $\frac{p^2}{E}$ is termed the MODULUS OF RESILIENCE, and p the PROOF STRESS.

Resin *or* **Rosin** (*Music*). A preparation obtained by dissolving ordinary rosin and straining it thoroughly. The best is made from Venetian turpentine, should be quite transparent, and when crushed not sticky. It is rubbed on the hair of stringed-instrument bows to facilitate the setting of the strings in vibration.

Resins. It is very difficult to define a resin. It is undoubtedly an exudation from the trunk and limbs of trees, existent or non-existent; but these exudations vary so much in all their properties that the terminology of them is wide, complicated, and in many cases contradictory. On the whole, it seems advisable to adopt the definition to be presently given, and to be guided by it in the subsequent remarks. The literature of the subject is scanty, and is the work of writers who have evaded the difficulty of definition. We propose to define a resin by three properties, as follows:

(1) It is a vegetable production.

(2) It solidifies after exudation from the tree.

(3) It is insoluble in water, but soluble in various organic liquids, such as chloroform, alcohol, oils, etc.

The second of these three essentials serves to establish a distinction between resins and balsams, such as copaiba and tolu, which are very closely related to the resins, and may, in fact, be regarded as substances intermediate between them and the essential oils. The third separates the resins from the gums proper, *e.g.* arabic and tragacanth, which are also vegetable exudations. The difficulty of the subject is well shown by the frequent use of the term "gum resin" and by the fact that the German word *gummi* means gum and also indiarubber, which may be regarded as a special kind of resin. In fact, there is a regular gradation from hard resins to soft resins, oleo resins, balsams, and essential oils; but with such small differences that it is practically impossible to draw any but arbitrary lines of demarcation. There is little doubt that the essential oils are the original material from which Nature has elaborated the balsams and resins by processes at present imperfectly understood, and therefore they cannot yet be reproduced artificially. There seems to be a strong probability that the action of atmospheric oxygen has played a considerable part in their formation, and that this formation has much analogy with the phenomena attending the solidification of a drying oil; but the fact remains that very little is known about the matter. The oxidation theory was, in fact, suggested by the behaviour of drying oils. Resins are classified as hard and soft, fossil and recent. The HARD RESINS, generally speaking, are also the fossil resins. The term fossil (dug up) does not necessarily mean that the resin won from the ground is the product of trees now extinct. It may be that this is sometimes the case. Amber, for instance, is probably the product of extinct trees. Nevertheless there are places, *e.g.* in New Zealand, where fossil resin is dug up on the sites of perished forests, and this product is indistinguishable from the fresh resin obtained from living trees in other parts of the country. The chief hard resins are amber and copal. AMBER is a fossil resin from an unknown tree. It was formerly dredged up on the southern shore of the Baltic, being washed by the waves from the submerged sites of ancient forests. Most of it is now, however, obtained by mining. It is used in fancy work, especially for the mouthpieces of pipes and cigar-holders, and for making the best and most expensive varnishes. Beads, too, are made of it. Its Greek name, *Electron*, has given us the word electricity, because it would seem that electrical attraction was first noticed in a piece of this substance which had been subjected to friction. COPAL comes from various trees. The best resins, those of Zanzibar and Mozambique, are the products of the gums *Trachylobium.* These give the hard copals. Animi or Indian copal, also known as Manila copal, is a softer resin, produced by *Valeria Indica.* The difference in nomenclature is geographical and commercial rather than a distinction of intrinsic value. Kauri or New Zealand copal is both a fossil and a recent resin. The African copals are dug up from depths of 3 or 4 ft. in districts from which the trees of their origin have entirely disappeared or perhaps become totally extinct; but in New Zealand we have the Kauri gathered from the living trees in one place and dug out of barren soil in another. Fossil copal has been dug out of the London tertiaries at Highgate. South American copal is a soft copal like animi and manila, but from a different tree, *viz. Hymenæa coubaril.* DAMMAR is practically equivalent to Kudri copal, and the difference in nomenclature is geographical only. *Dammara australis* is the tree responsible for both sorts. Alive it produces dammar. Kauri is the legacy of dried resin left behind by former generations of the same tree. It should be noted that the name Agathis is in some books substituted for the older name Dammara. These hard resins have the curious property of requiring to be heated before they can be dissolved in oil and turpentine for varnish making. "Copal running," as the process is called, requires a fairly high temperature, and yields a distillate containing substances of some value, although the vapours are usually allowed to escape into the open air. The only SOFT RESIN calling for notice is the chief of all the resins, and it lends itself to a larger variety of uses than its congeners. While other resins are restricted in their use to the making of varnishes, rosin (pine tree resin), while doing good service to the varnish maker, is largely used as a cement and for the preparation of resinates. It makes, like shellac, an excellent medium for stopping leaks in china and earthenware vessels. Shellac, which is largely used for stopping up cracks in jugs, teacups, etc., as it will stand hot water, is distinctly inferior to rosin for the purpose. Colophony, or rosin, is the coagulated exudation obtained from cuts in the bark of trees belonging to several species of Pinus, largely grown in America and on the west coast of France. The crude resin yields on distillation oil of turpentine first and then a mixture of liquids of higher boiling temperature known as rosin oil. This oil is largely employed in making the cheaper varnishes, lamp-black for printers' ink, and also, in some places on the Continent, illuminating gas. It is not used, however, for this last purpose in Great Britain, although very high illuminating power is claimed for the gas. The final residue of the distillation is pitch, which is used for caulking seams and for waterproofing the inside of casks. It must not be confounded with coal-tar pitch. Colophony is largely used for varnish making, for making violin bows grip the strings, as a flux by plumbers in

soldering, for filling soaps, and for the preparation of resinates. All cheap varnishes contain colophony, and one of the "copal" varnishes, for which high prices are charged, contains little else except the solvent. The use of rosin in soapmaking is one of its most important applications. Boiled with an alkali, it produces an alkaline resinate, which has at least this much of a soap about it, that it lathers well. This circumstance, together with the fact that rosin is much cheaper than soap, has naturally drawn the attention of soap boilers to it. The alkaline resinates have, however, a much more legitimate use as a raw material for the preparation of the resinates of heavy metals, such as manganese and lead. These resinates have an extended application in the manufacture of driers and of paints. We may conclude with a brief notice of LAC. This does not conform altogether to the first requisite of a resin as defined above, since, although it is primarily a vegetable substance, it is worked up and secreted by an insect; still it has a close connection with the true resins. The products of the lac insect are purified first to seed lac and finally to shell lac (shellac). Spirit varnishes are made from it and also French polish, and it is the chief ingredient of sealing wax. It is the only animal product which conforms to the second and third requisites of a resin.—A. S. J.

Resist. A substance or composition which is temporarily applied to certain parts of the surface of another substance to prevent an acid, dye, mordant, etc., from affecting those parts, *e.g.* the wax applied in a thin coat to glass previous to etching. *See* GLASS MANUFACTURE.

Resistance (*Elect.*) The ratio of a constant electromotive force to the steady current produced by it in any conductor is termed the ELECTRICAL RESISTANCE of the conductor. If the length of a conductor be l and its area of cross section a, then its resistance R is given by the formula $R = \sigma \frac{l}{a}$. If l and a are each unity, then σ is the resistance of the conductor. It is termed the SPECIFIC RESISTANCE.

—— (*Eng.*) That which opposes the action of a force; it is therefore a force itself. The term is applied especially to frictional forces.

——**, Measurement of** (*Elect.*) The measurement of the electrical resistance of a conductor is effected in practice by comparison with a known resistance. The principal methods by which this comparison is made are as follows: (1) METHOD OF SUBSTITUTION: The unknown resistance is connected in series with a cell or battery of constant electromotive force and an ammeter or a galvanometer, by which the current which flows through the circuit can be measured. Let X be the value of the resistance, E the E.M.F., and C the current, S the resistance of the rest of the circuit. Then by Ohm's Law (*q.v.*)

$$C = \frac{E}{X + S}$$

An adjustable resistance or set of resistances is now substituted, and its value adjusted until the current has the same value as before. Let R be this resistance. Then

$$C = \frac{E}{R + S}$$

But as the current is unchanged in amount, and E is constant, $X + S = R + S$ or $X = R$. If R cannot be adjusted to give the same current, the values C_1 and C_2 of the current must be observed; then

$$\frac{C_1}{C_2} = \frac{\frac{E}{X+S}}{\frac{E}{R+S}} = \frac{R+S}{X+S}$$

To find X in terms of R it is now necessary that S be known. In the application of this method to the comparison of very high resistances, which is its chief practical use, the value of S is very small compared to R and X, and in this case

$$\frac{C_1}{C_2} = \frac{R}{X}$$

(2) METHOD OF FALL OF POTENTIAL: If C be the current in a conductor of resistance R, the difference of potential E_1 between the ends of the conductor is CR. If the same current flow through another conductor of resistance X, the difference of potential E_2 is CX. Thus

$$\frac{CX}{CR} = \frac{E_2}{E_1} = \frac{X}{R}$$

The known and unknown resistances are connected in series with each other and with a constant battery; the differences of potential E_1 and E_2 are observed by means of a voltmeter or a high resistance galvanometer. This method is used for the comparison of very small resistances. (3) MEASUREMENT BY WHEATSTONE'S BRIDGE: This is the method which is used in practice for the measurement of the great majority of resistances; the form known as the Post Office Box can be used for measuring resistances from ·1 ohm to 1,000,000 ohms, though the extreme range is not used when considerable accuracy is required. The method is described under WHEATSTONE'S BRIDGE (*q.v.*)

Resistance Coil (*Elect.*) A coil of insulated wire whose resistance has been adjusted to a stated value. In forming the coil a wire whose resistance is somewhat greater than that of the finished coil is first doubled in the middle, bringing the two ends together. The doubled wire is then wound on a reel, and the resistance measured, the wire being shortened until the proper value is attained. The ends are then connected to terminals placed on the top of the reel, and the whole enclosed in a suitable case.

Resolution (*Music*). A term applied to the proper and satisfactory progression of discords (*q.v.*)

Resolution of a Force. Finding the magnitude and direction of two or more forces such that their resultant (*q.v.*) is identical with the force which is being resolved. The separate forces, which may be substituted for the given force, are termed its COMPONENTS. If they are at right angles to each other, they are termed RECTANGULAR COMPONENTS. If f be the given force, and θ the angle which one component makes with the original force, then the value of this component is $f \cos \theta$, and that of the other component at right angles to it is $f \sin \theta$.

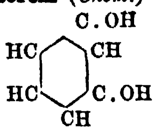
Resonance (*Phys.*) If any body (or system of bodies) be acted upon by a succession of impulses or vibrations, which recur at intervals corresponding to its own natural period of vibration, it will itself be caused to vibrate. This is termed RESONANCE. The phenomenon is very easily observed in the case of sound: *e.g.* a stretched string is readily set in vibration if a note of the same pitch (frequency) as

its own fundamental tone be sounded in the vicinity. Resonance is often made use of in the detection of vibrations which are too feeble to be detected by the unaided ear.

Resonant. As applied to substances, *e.g.* porcelain, metals, etc., indicates that they give a ringing sound when struck.

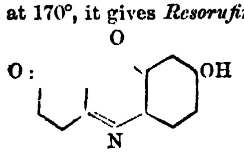
Resonator (*Phys.*) An object used in the detection of vibrations by Resonance (*q.v.*) In acoustic experiments, hollow vessels of approximately spherical form are often used, as their overtones (*q.v.*) are not readily produced, and therefore they resound to their fundamental tone only.

Resorcin (*Chem.*)



(Metadihydroxybenzene.)

A white solid crystallising in needles or plates; melts at 118°; boils at 277°; soluble in water, alcohol, ether; insoluble in chloroform; tastes sweet; it is a powerful antiseptic, and is used in medicine in some skin diseases. Ferric chloride gives a dark violet colour with a solution of resorcin. Reduces boiling Fehling's solution and boiling ammoniacal silver nitrate. With bromine water it forms tribromresorcin (MP 111°), which is insoluble in water (basis of method for estimation). Fused with caustic soda, it gives a 65 per cent. yield of phloroglucin, a little pyrocatechol and tetroxydiphenyl. Heated with phthalic anhydride alone or with a little sulphuric acid, it forms fluorescein (*q.v.*); other dibasic acids give similar compounds—*e.g.* succinic and tartaric acids. Heated with nitrobenzene and concentrated sulphuric acid at 170°, it gives *Resorufin*



which forms small brown needles, which dissolve in alkalis with a crimson colour showing scarlet fluorescence, and on bromination form *Resorcin blue*, which is tetrabromresorufin—a dye giving blue shade with brown fluorescence on silk and wool. *See also under* LACMOID. Resorcin is obtained when certain resins, especially asafœtida and galbanum, are fused with caustic potash. It is also obtained when many meta-disubstituted benzene derivatives are fused with caustic soda; also from some ortho- and para-derivatives. On the large scale it is made from benzene by heating with fuming sulphuric acid to form metabenzenedisulphuric acid, which is made into the calcium salt with chalk, then into the sodium salt with sodium carbonate,—the sodium salt is fused with caustic soda. From the aqueous solution amyl alcohol dissolves out the resorcin.

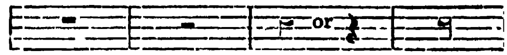
Resorcinol (*Chem.*) *See* RESORCIN.

Respond (*Architect.*) A half pillar attached to a wall and supporting an arch. It usually occurs at each end of a range of pillars.

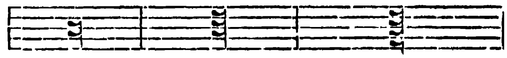
Rest (*Eng.*) A support for a tool, especially a turning tool. *See* HAND REST, SLIDE REST, *etc.*

—— (*Music*). A sign indicating silence. There is a rest corresponding to each note and having exactly the same time duration as that note. The following is a list of rests with the respective shapes:

The Large or Maxima. The Long. The Breve.



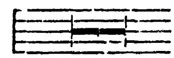
The Semibreve. The Minim. The Crotchet. The Quaver.



The Semiquaver. The Demi-semiquaver. The Hemidemi-semiquaver.

In modern music it is usual to mark rests of more than two bars' duration thus, placing the number of bars over:

17



The semibreve rest is used for a complete bar's rest in either triple or common time.

Restitution, Coefficient of (*Mech.*) If two elastic spheres collide, their relative velocity after impact bears a certain ratio to their relative velocity before impact: this ratio is termed the COEFFICIENT OF RESTITUTION.

Restrainer (*Photo.*) *See* RETARDATION.

Restraining (*Photo.*) *See* RETARDATION.

Resultant. The Resultant of a system of forces is that single force which, when acting alone, produces the same effect as the separate forces, so far as regards the motion of the body which is acted on. (It does not follow, however, that the resultant will produce the same stresses in the body as the separate forces do.) The resultant of two velocities, accelerations, or other vectors (*q.v.*) is obtained in a manner similar to the resultant of two forces.

Retaining Rings (*Eng.*) Flange rings used to bind together the tyre and the central portion of railway wheels when built with wooden bodies.

Retaining Wall. A wall built to resist the pressure of earth or water.

Retardation. In general the checking or slowing down of any movement, or the application of a force or other agent which causes such checking.

—— (*Music*). A term applied by some musicians to suspensions which resolve upwards instead of downwards. *See* SUSPENSIONS.

—— *or* **Restraining** (*Photo.*) Causing a developer to act more gradually than it would otherwise do, by the addition of some substance (*e.g.* potassium bromide), which is termed the RESTRAINER *or* RETARDER.

Retarder (*Photo.*) *See* RETARDATION.

Retarders (*Eng.*) A flat strip of metal twisted into an elongated spiral, and placed in boiler tubes to increase the heating action of the furnace gases and break up the "steam lines." Sometimes they are made of fireclay; there are various patented forms.

Retarding Coil (*Elect.*) A choking or impedance coil.

Reticulated. Resembling network, having lines or veins crossing like a net.

Reticulated Tracery (*Architect.*) A form of tracery resembling network, used in the windows of the Decorated period of Gothic architecture.

Retort (*Chem., Met., etc.*) A vessel in which a substance is heated in order to cause a volatile constituent to be given off so that it may be condensed and separated from the original body. Retorts are made in a great variety of forms and many different materials, according to the purpose for which they are intended.

Retorted (*Her.*) Intertwined frettewise. Branches of trees are sometimes thus blazoned.

Retouching (*Art*). A modification or improvement carried out in a work of art. An alteration made to a photographic *cliché* to remedy the modelling.

Retrograde Motion (*Astron.*) The apparent westward motion of planets which occurs periodically, owing to the movements of the earth and the planet.

Retting *or* **Rotting** (*Linen Manufac.*) The term applied to the process of steeping the flax stalks in water. This dissolves out the gummy matter which surrounds the fibre and enables the "bone" of the plant to be broken up and dispersed in the process of scutching, without causing any unnecessary waste of fibre. *See* LINEN MANUFACTURE.

Return (*Architect., etc.*) A change in direction of a moulding such as that frequently used in the termination of a hood mould (*q.v.*)

—— (*Plumb.*) The pipe in which the water returns to the boiler in hot water circulation.

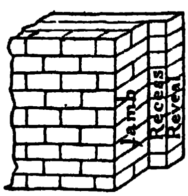
—— *or* **Point Pass** (*Textiles*). *See* ENTERING.

Returned Bead (*Carp. and Join.*) Beadwork on the side and edge of the same angle.

Returned Nosing (*Join.*) The moulding turned round the end of a stair tread.

Reuleaux's Valve Diagram (*Eng.*) *See* VALVE DIAGRAMS.

Reveal (*Build.*) The portion of the surface of a wall in an opening or recess (*e.g.* a door or window) between the edge or arris and the structure (*e.g.* window frame) placed in the recess. In the case of a window in an ordinary brick building the reveal is usually 4½ or 9 inches wide.

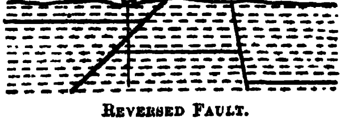


REVEAL.

Reverberatory Furnace. *See* FURNACES.

Reverse (*Coins*). The back of a coin or medal, *i.e.* the side opposite to the face or obverse (*q.v.*)

Reversed Faults (*Geol.*) In a normal fault the inclination of the plane of the fault is usually only a small number of degrees from the vertical, and is



REVERSED FAULT.

"forward at the foot," or advances in the direction of the downthrow side of the fault (*see b*, below). In a reversed fault the inclination or "hade" is in the opposite direction, so that a vertical shaft cutting the fault would pass twice through the same bed of rock, on either side of the fault, as at *a*.

Reversed Mould (*Foundry*). A kind of pattern made in metal or plaster, and used for producing a number of moulds when numerous similar castings are required.

Reverse Jaws (*Eng.*) Jaws on a lathe chuck which can be used for holding a ring or hollow cylinder, contact being made by the jaws with the inside of the ring, and the jaws moved outward till the object is firmly gripped.

Reversible Engine (*Phys.*) A "perfect engine" (*q.v.*) is said to be reversible, for the cycle of operations can (theoretically) be worked backwards. In this case the engine will take a quantity of heat H (measured in mechanical units) from the receiver or cool body, which is at a temperature θ_2, a certain amount of work, W, will be converted into an amount of heat *h*, and the larger amount of heat H + *h* will be given up to the hot body or source at a temperature θ_1. The ratio of work and heat is the same as in the case of the same engine when converting heat into work, *viz.*

$$\frac{W}{W+h} = \frac{\theta_1 - \theta_2}{\theta_1}$$

Reversible Reactions (*Chem.*) Reactions which may go, according to the conditions of experiment, in either direction. Thus, if sulphur dioxide is passed into water containing iodine in solution, we get the reaction

$$SO_2 + 2H_2O + I_2 = H_2SO_4 + 2HI.$$

But if strong sulphuric acid is added to a strong solution of hydriodic acid, we have the reverse of the above reaction—

$$H_2SO_4 + 2HI = SO_2 + 2H_2O + I_2.$$

Such reactions are usually written—

$$SO_2 + 2H_2O + I_2 \rightleftarrows H_2SO_4 + 2HI.$$

They are very numerous, and play a very important part in chemistry. *See* DISSOCIATION, MASS ACTION, PRECIPITATION.

Reversing (*Eng.*) Changing the direction of revolution of an engine or other mechanism.

—— (*Moulding*). Making an ordinary mould from a REVERSED MOULD (*q.v.*)

Reversing Back (*Photo.*) A frame (carrying the dark slide) which can be fixed to the camera in a horizontal or vertical position.

Reversing Countershaft (*Eng.*) A shaft from which a machine can be driven either by an open or a crossed belt, thus allowing the direction of rotation to be reversed.

Reversing Engine (*Eng.*) An engine which can be reversed, usually by LINK MOTION (*q.v.*) Locomotives, marine engines, etc., are almost invariably fitted with this gear; factory engines are not. Gas engines and steam turbines cannot, as a rule, be reversed by any form of valve or other gear.

Reversing Gear (*Eng.*) Any mechanism for reversing the direction of rotation. In engines it usually consists of LINK MOTION (*q.v.*) or a LOOSE ECCENTRIC (*q.v.*); in other machinery, of belts and countershafts or of trains of gear wheels.

Reversing Layer (*Astron.*) A thin stratum of a gaseous envelope lying just above the photosphere of the sun, the absorption of which is supposed by some astronomers to give rise to the Frauenhofer lines.

Reversing Link (*Eng.*) The slotted link used in LINK MOTION (*q.v.*)

Revise (*Typog.*) An impression of a forme taken for the purpose of seeing that all corrections have been made, etc. *See* READER.

Revolution (*Astron.*) The motion of one body round another, like the earth round the sun.

Revolving Boiler (*Paper Manufac.*) An apparatus used for digesting or boiling rags or straw.

Revolving Flats (*Cotton Spinning*). A series of slowly travelling bars on a carding engine, covered with wire filleting on their surfaces for the purpose of carding and cleaning the cotton as it goes over the large cylinder. Their travelling or revolving motion is for the purpose of subjecting a number of them in turn to a stripping process whilst the others are in action. By this means the filleting is always kept free from dirt, fluff, etc.

Revolving Furnace (*Met.*) A furnace containing either a flat circular hearth, revolving about an axis which is vertical or nearly so, or else having a tubular body, rotating about a horizontal or slightly inclined axis. Such furnaces are used in various processes for puddling or for steel manufacture. They are little used in this country.

Rh (*Chem.*) The symbol for RHODIUM (*q.v.*)

Rhætic Beds (*Geol.*) A geological formation of marine origin and of small thickness in Britain, which occupies a position between the base of the Lias and the top of the New Red. It is characterised nearly everywhere by the fossil mollusca *Avicula contorta*, *Cardium rhæticum*, and *Pecten valoniensis*. In the Rhætic Alps this formation attains to a much greater thickness.

Rhamnose (*Chem.*) $CH_3.(CHOH)_4.CHO$ (Isodulcite). A sugar which crystallises with one molecule of water in shining monoclinic crystals which show triboluminescence. On heating at 100° it loses its water of crystallisation, and on prolonged heating at this temperature forms an anhydride; soluble in water, also soluble in alcohol, but much less so than in water; its solution is dextrorotatory, but when quite freshly prepared its solution is lævorotatory, becoming dextrorotatory after about nine minutes. Rhamnose does not undergo alcoholic fementation. It reduces Fehling's solution and ammoniacal silver nitrate; on reduction with sodium amalgam it yields the corresponding alcohol (Rhamnite), $CH_3(CHOH)_4CH_2OH$; on oxidation with bromine water it yields the corresponding acid (Rhamnonic acid), $CH_3(CHOH)_4COOH$; on oxidation with nitric acid it yields oxalic acid and a trioxyglutaric acid, $COOH(CHOH)_3COOH$; silver oxide oxidises it to aldehyde and acetic acid. It forms a tetranitrate and a tetrabenzoate. Like dextrose, it forms an oxime with hydroxylamine, an osazone with phenylhydrazine, and a cyanhydrin with hydrocyanic acid. Rhamnose occurs in a state of combination in several glucosides, especially in quercitrin and in hesperidine. It is prepared from quercitrin by hydrolysis with dilute sulphuric acid; after filtering, the liquid is saturated with barium carbonate, again filtered, concentrated, and allowed to crystallise, when crude rhamnose separates. A further yield is got from the mother liquor by adding absolute alcohol. The crude crystals are purified by recrystallisation from water or alcohol.

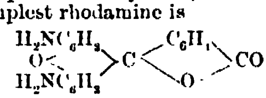
Rhea (*Botany*). A textile fibre known also as Ramie fibre or China grass, obtained from the stem of a Chinese nettle, *Boehmeria nivea* (order, *Urticaceæ*).

Rheostat (*Elect.*) An electric resistance which can be continuously varied within certain limits.

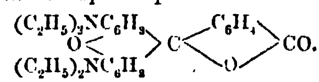
Rhizome (*Botany*). The stout underground stem ("rootstock") seen in the Iris, Solomon's Seal, and Wood Anemone. Its tissues are filled with various food materials, such as starch, etc.

Rhodamine. *See* DYES AND DYEING.

Rhodamines (*Chem.*) Dyes formed by the condensation of meta-amidophenol and its alkyl derivatives with phthalic and other anhydrides of dibasic acids, especially succinic acid. They are similarly constituted to the condensation product of resorcin and phthalic anhydride, FLUORESCEIN (*q.v.*); thus the simplest rhodamine is



The dye Rhodamine B is the hydrochloride of diethylmeta-amidophenolphthalein—



It forms green crystals, soluble in water and in alcohol; it dyes silk a strongly fluorescent bluish-red; cotton mordanted with tannin a violet red, not fluorescent unless the cotton has been oiled. It is prepared by heating diethylmeta-amidophenol with phthalic anhydride and concentrated sulphuric acid. The diethylmeta-amidophenol may be prepared from resorcin by heating it with ethylamine and ethylamine hydrochloride in aqueous solution under pressure at 200°. Other rhodamines are got by substituting succinic anhydride for phthalic anhydride.

Rhodium (*Chem.*) Rh. Atomic weight, 103. A rare metal resembling palladium and in a less degree platinum. It occurs in small quantity in platinum ores. It is white, and only fuses in the oxyhydrogen flame, and is in mass insoluble in acids. Occasionally used with platinum in making thermo-couples. It forms a chloride, $RhCl_3$, and oxides, RhO, Rh_2O_3, and RhO_2: it also forms complex ammonia compounds.

Rhodochroisite (*Min.*) Carbonate of Manganese, $MnCO_3$. Usually contains about 75 per cent. of carbonate of manganese, with other carbonates to 25 per cent., probably as replacement products. Rhombohedral, in curved rhombs of a flesh red colour. Also called DIALOGITE. From Oswestry in Shropshire, Warwickshire, co. Clare, Transylvania, Saxony, etc.

Rhodonite (*Min.*) Silicate of Manganese, $MnSiO_3$. Manganous oxide = 54·1, silica = 45·9. Triclinic; usually occurs massive. Colour, flesh red, changing to a black on exposure. It is used in glass and earthenware glazing to give violet tints. From Cornwall and Devon in England, Sweden, the Harz, Siberia, and several places in North America.

Rhomboid. A parallelogram whose adjacent sides are unequal and whose angles are not right angles.

Rhomb Spar (*Min.*) A ferruginous variety of DOLOMITE (*q.v.*)

Rhombus. A parallelogram whose sides are equal, but whose angles are not right angles.

Rhubarb. *Rheum officinale* (order, *Polygonaceæ*). The root, when dried, forms the medicinal rhubarb. It is imported from China. Several varieties are used, the best known being the Russian ("Turkey") Rhubarb. The garden forms are *R. rhaponticum* and *R. undulatum*.

Rhymer. A REAMER (*q.v.*)

Rhyolite (*Geol.*) An eruptive rock, in most cases a lava, of subacid or even acid composition, which is characterised by potash felspar crystals in a lithoidal ground mass. The rock often shows crumpled bands of alternately lighter and darker colours. The crumbling has arisen from the flowing movement of the rock after its solidification was far advanced.

Rhythm (*Music*). Consists of (1) proportionate duration of sounds, (2) symmetrical grouping, (3) regular accentuation. It signifies the arrangement by which the cadences are placed; hence a musical composition may be of two bar, four bar, five bar, or eight bar rhythm, and according as these cadences fall, so the composition is of REGULAR or IRREGULAR RHYTHM. Ernst Pauer says: "The rhythmical construction of a musical piece cannot be definitely fixed according to a pattern or an arbitrary rule. The law that has to be obeyed does not restrict freedom of fancy and feeling; *variety* is necessary as well as *unity*. Rhythm may be described as the art of the versifier, necessary, but yet only supplementary, to the genius of the poet or composer; for although rhythm will heighten the beauty of a melody, it can, even when used with the greatest cleverness, never succeed in ennobling vulgarity or triviality in music" (*Primer of Musical Forms*).

Rib (*Carp. and Join.*) One of the curved rafters of a roof or circular framing.

—— (*Eng.*) A projecting part, usually forming a ridge or flange, whose function is to strengthen the object across which it runs. In ships the ribs are the vertical portions of the framework.

—— (*Textile Manufac.*) A fabric differing from a rep in that the lines may be either across or lengthways of the fabric. It is a common type of worsted pattern.

Riband (*Her.*) A diminutive of the bend, of the same dimensions as a cotise but with the ends cut off or "couped," and not reaching the edges of the shield.

Rib and Panel Vault (*Architect.*) The form of vaulting which was introduced in England at the close of the Norman period, and which is one of the characteristics of Gothic architecture. The ribs are the constructional parts of the vault, the panels, cells, or severies being merely filled in between them. In this system of vaulting the thrusts are concentrated upon definite parts of the wall, which are designed to counteract them. In early rib and panel vaults the only ribs used were the formerets or wall ribs, the transverse ribs, and the diagonal ribs. In later work ridge ribs and tiercerons (intermediate ribs between the transverse and diagonal ribs) were introduced, and finally lierne ribs, which are merely decorative, were added. *See* SEXPARTITE VAULT, BARREL VAULT, FAN VAULT, BOSS, *and* LIERNE RIB.

Ribbon Brake (*Eng., etc.*) A BAND BRAKE (*q.v.*)

Ribbon Jasper. *See* AGATE.

Ribbon Saw (*Eng.*) A BAND SAW.

Rice (*Botany*). The grain of the Rice plant, *Oryza sativa* (order, *Gramineæ*), an annual grass grown under hot, moist conditions in tropical countries. Rice in the husk is termed "Paddy." Rice is remarkably deficient in proteids, fats, and salts. It is essentially a carbohydrate food, and is extremely digestible when well cooked. It should be steamed rather than boiled, otherwise it loses some of its very small quantity of proteid and salts.

Rich Lime (*Build.*) *See* FAT LIME.

Ricinoleic Acid (*Chem.*)

$CH_3(CH_2)_5 . CHOH . CH_2 . CH : CH . (CH_2)_7 . COOH.$

A soft crystalline solid; melts at 17°; soluble in alcohol and ether; dextrorotatory. With bromide it forms a dibromide. Heated with iodine and amorphous phosphorus it yields iodo-oleic acid, which yields stearic acid on reduction with zinc and hydrochloric acid. Nitrous acid converts it into the isomeric ricinolaidic acid. Fused with caustic soda it gives secondary octyl alcohol—

$$\begin{array}{l} CH_3 \\ | \\ CHOH \\ | \\ C_6H_{13} \end{array}$$

and sebacic acid, $(CH_2)_8(COOH)_2$. It occurs as its glyceryl ester in castor oil, of which the ester is the chief constituent. It is prepared by hydrolysing castor oil with caustic soda, and purifying the crude acid by crystallising the barium salt.

Riddle. A SIEVE.

Riddlings. Coarse material left in the sieve after sifting. The term is chiefly confined to the foundry.

Ridge (*Build.*) The upper angle of a roof.

—— (*Foundry*). A horizontal channel in the sand of a mould for leading metal to some definite point during pouring.

Ridge Board (*Build.*) The board to which the top ends of the rafters of a sloping roof are fixed.

Ridge Course (*Build.*) The course of slates or tiles next to the ridge of a roof.

Ridge Roll (*Build.*) A piece of wood of approximately circular section fixed along the top edge of the ridge board (*q.v.*)

Ridge Tiles (*Build.*) The ornamental tiles fixed on the ridge board of a roof.

Riding (*Eng.*) A belt is said to ride when it mounts on to the flange of a flanged pulley; a driving chain, when it mounts the cogs so that it rests on the tips of the teeth; two gear wheels, when they become displaced so that the tips of the teeth come in contact.

Riffler (*Eng., etc.*) A file whose axis or centre line is curved.

Rigger (*Eng.*) A name sometimes applied to a belt pulley.

Right Angle. *See* ANGLE.

Right Ascension (*Astron.*) The angular distance, measured along the equator between the First Point

of Aries and the declination circle of the star (*i.e.* the secondary great circle to the equator, which passes through the star). Commonly denoted by "R.A."

Right Handed Screw. A screw whose thread runs upward from left to right when viewed with the axis in a vertical position. If the screw be turned in its nut in a clockwise direction, it recedes from an observer looking along its axis. This is the common form of screw thread; the reverse or left-handed screw is only rarely used.

Right Line. A STRAIGHT LINE (*q.v.*)

Rigid Body. A rigid body is one in which no relative motion of the particles can be produced by the application of forces. No perfectly rigid body exists; but from the engineers' point of view the harder metals (*e.g.* cast iron) may usually be considered rigid.

Rigidity. In general terms the power possessed by a body of resisting changes of shape. The MODULUS OF RIGIDITY or COEFFICIENT OF RIGIDITY is often termed simply the RIGIDITY. It is the relation of the SHEARING STRESS to the SHEAR or SHEARING STRAIN. *See also* SHEAR

Rigore, Con; Rigoroso (*Music*). With exactness, strictness.

Rilles on the Moon (*Astron.*) Trenches with raised sides more or less steep.

Rimer (*Eng., etc.*) A REAMER (*q.v.*)

Rim Wheel (*Cotton Spinning*). The wheel on the headstock of a mule which transmits motion to the tin roller and spindles.

Rinforzando (*Music*). Abbreviated *rinf.*, *rf.*, or *rfz.* Reinforcing the power of a musical phrase. It is to a phrase what sforzando is to single sounds.

Ring (*Build.*) A brick arch consists of a number of half brick rings one above the other.

Ring Armatures (*Elect. Eng.*) *See* ARMATURES.

Ring Compounds (*Chem.*) Suppose a compound formed by joining to a given group two other groups or more than two; then if the last group joined up be connected with the first, we have what is called a ring compound. In practice rings are not formed in this way. An actual example is as follows:—glycerine has the formula—

$$\begin{array}{c} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

with bromine and phosphorus it forms allyl bromide—

$$\begin{array}{l} CH_2 \\ \| \\ CH \\ | \\ CH_2Br \end{array}$$

This compound unites with hydrobromic acid to form trimethylene bromide—

$$\begin{array}{l} CH_2Br \\ | \\ CH_2 \\ | \\ CH_2Br \end{array}$$

The latter, when acted on by sodium, forms trimethylene—

$$\begin{array}{c} CH_2 \\ H_2C \diagup\!\!—\!\!\diagdown CH_2 \end{array}$$

which is a ring compound. When the ring is made up by union of atoms of the same kind it is called an isocyclic ring; when the atoms are not all alike it is called a heterocyclic ring. Benzene and naphthalene are important examples of isocyclic ring compounds. Pyridine, Quinoline, Furfurane, Pyrazole, Pyrrole, the Lactones are important examples of heterocyclic ring compounds.

Ringelmann's Smoke Scale. A series of white cards about 8 in. square ruled at right angles into squares. They are graduated (by increasing the thickness of the lines) from all white to nearly black. The white spaces are cut out, and, by looking at "black" smoke through this screen, its degree of blackness can be gauged by the screen and the smoke appearing to be of the same shade. Solid ruled cards may also be merely compared with the smoke emitted and the shade judged.

Ring Frame (*Cotton Spinning*). A continuous spinning machine suitable for warp yarns up to fifty counts. It produces a thread less fibrous than the mule and rather rounder, but not so elastic, nor will it spin as soft a thread as the mule. For ordinary spinning it has greater productive powers per spindle than the mule, and may be attended to by a female. The drawing, twisting, and winding of thread on to bobbin are performed simultaneously, a small metallic ring called a traveller being used for the purpose. So far it has not been very successful in spinning weft yarns or fine counts.

Ring Micrometer (*Astron.*) A narrow metal ring attached to a thin piece of glass in the focal plane of an eyepiece. Used in conjunction with a telescope. *See* MICROMETER.

Rings of Saturn (*Astron.*) The planet Saturn is surrounded by a host of small satellites, which all lie in one plane, and constitute a series of rings about the planet's Equator.

Ring Traveller (*Cotton Spinning*). A small metallic ring which is connected to the thread, being spun on a ring frame, so as to impart twist and also assist in the winding of thread on to bobbin. *See* RING FRAME.

Ripidolite (*Min.*) One of the Chlorite Group of minerals now more often known as Clinochlore. It is a monosymmetric basic silicate of magnesium and aluminium, $5MgO \cdot Al_2O_3 \cdot 3SiO_2 \cdot 4H_2O$. Chiefly of interest as a rock forming mineral.

Ripieno (*Music*). Supplementary or filling up parts.

Ripper (*Build.*) A tool used by slaters for cutting the nails under the slates when removing them.

Ripping (*Carp.*) Cutting timber in the direction of the grain.

Ripple (*Phys.*) In general a small wave on the surface of a liquid. The term is confined in strictly scientific language to those waves which are propagated chiefly by the surface tension of the liquid in which they are produced.

Ripple Marks (*Geol.*) A waved surface left upon sand and similar deposits by a to and fro movement of either wind or water. The ripples are usually formed either directly at the surface or else beneath

a small depth of water; but their presence has been detected on a sandy floor of the sea at a depth of a hundred feet or more. Sand ripples are very characteristic of desert regions. Ripple marks occur commonly on the surface of deposits of volcanic dust.

Rippling (*Linen Manufac.*) When the flax plant is ripe, seed capsules form about the size of peas, and contain the flax seed or linseed. These are usually cleared off before the stalks are retted by drawing the plant through a coarse steel comb. The process is termed Rippling. *See* LINSEED OIL (*under* OILS).

Rip Saw (*Carp. and Join.*) A saw used for cutting timber in the direction of its fibres, and having about two and a half to three teeth to the inch.

Rise (*Build.*) The height of the crown of an arch above the springing. The height of a step, or of a roof above the wall plates. *See* ARCH.

—— (*Typog.*) The term was originally used when a forme could be lifted from the imposing surface without any of the types falling out. It is now used when, through faulty locking-up or bad justification, the forme "springs" and the spaces or furniture "rise" to the level of the type face.

Riser (*Build.*) The vertical part of a step. *See also* STAIRCASES.

—— (*Foundry*). An opening extending from the cavity of a mould up through the sand to the surface. When liquid metal is poured in through the gates the air in the mould rushes out of the risers, and, when the mould is full, liquid metal rises in them, showing that the mould is full. The risers also form a channel by which dirt, scoriæ, etc., can be swept out of the cavity by the rush of the molten metal, instead of accumulating in the top of the mould and rendering the upper part of the casting unsound.

Risers (*Typog.*) The material upon which stereo and electro plates are mounted and fixed to render them "type high."

Rising and Falling Saw (*Carp.*) A circular saw which can be caused to project above its table to a greater or less extent by raising or lowering the spindle, which is provided with mechanism for the purpose. It is used for cutting grooves of various depths.

Rising and Falling Table (*Eng.*) Certain machine tools (*e.g.* drills, milling machines) are sometimes fitted with a table of this kind, *i.e.* one which can be raised or lowered either by hand or automatically.

Rising and Setting (*Astron.*) The instant that a celestial body comes into or disappears from view, when the observer has a perfectly clear horizon.

Rising Gate (*Foundry*). A RISER (*q.v.*)

Rising Main. (1) The vertical water pipe in a building that issues from the main pipe. (2) The pipe that supplies a cistern, etc.

Risoluto (*Music*). With resolution.

Risvegliato (*Music*). In an animated manner.

Ritardando (*Music*). Gradually decreasing the speed. *Cf.* ACCELERANDO.

Ritenuto (*Music*). Slower, *i.e.* the whole passage so marked is *at once* to be taken slower, whereas ritardando means *gradually* decreasing the pace.

Rivers (*Geol.*) Solar energy elevates large quantities of vapour, and gravitation coming into play after the vapour is again condensed, the water of rivers is thereby set in motion, enabling them to perform a considerable amount of geological work. Most of it is of a mechanical nature, and consists, in the first instance, of the removal of part of the rock surface in contact with the moving water; but part of the effect produced arises from chemical causes. In the higher parts of river valleys the rate of erosion of the river bed in a vertical direction is usually in excess of that of the sides of the valley above the river bed. Hence, under the combined effect of lateral and vertical erosion, the sides of river valleys, in the hilly part of their track, are usually characterised by steep slopes. The chief function of rivers, regarded from a geological point of view, is as agents of transport. Rock material, disintegrated and decomposed by the action of sub-aërial forces, sooner or later finds its way into rivers, which transport the coarser materials to lower levels chiefly during floods, and constantly transfer the materials that are in suspension, as well as those that are held in solution, from the land to the sea, where these materials are eventually left in a more or less stratified form. *See* CLOUDS AND RAIN.

Rivet. A short cylindrical fastener of metal with a strong head at one end, used for forming a joint between overlapping plates, etc. The rivet is inserted in a hole which has been previously drilled or punched through the plates and is then "closed"; *i.e.* a second head is formed by hammering either in the cold or while the rivet is still hot from the rivet forge. Copper rivets are always closed in the cold; iron or steel ones are nearly always heated. The closing may be done by a machine worked by hydraulic or other power; the use of a machine is quicker, and does not involve the jarring of the plates which is produced by excessive hammering.

Riveted Joint (*Eng.*) Used in girders, boilers, etc. It is suitable for joints which have to stand a tangential or shearing force—that is, where the rivets have to resist forces which tend to move the plates past each other.

Riveted Stays (*Eng.*) Stays or tie rods whose ends are riveted over, *i.e.* heads are formed on them by hammering, as in the case of an ordinary rivet. This method of fastening a stay rod is usual in boilers; but the ends are often screwed into the holes first, and the rivet head formed on the projecting end of the screw.

Rivet Forge (*Eng.*) A small portable forge used for heating rivets.

Rivet Holes (*Eng.*) Drilled or punched holes passing right through plates which are to be riveted together. Drilled holes are much the better.

Riveting Machine (*Eng.*) A machine resembling a punching machine in action, but furnished with dies, one of which supports the head of a rivet, while the other closes up or forms a head on the other end. It is commonly worked by a hydraulic ram.

Rivet Steel. Mild steel of good quality is often used instead of wrought iron for rivets. It should have considerable tensile strength, and care must be taken to prevent overheating in the rivet forge, as if the steel become "burnt" it is practically useless.

Road Locomotive. A TRACTION ENGINE (*q.v.*)

Road Metal (*Civil Eng.*) Stone suitable for road making; it is crushed or broken to a suitable size by hand or machine

Roan (*Leather Manufac.*) Tanned sheepskin when dyed and finished is known as roan. Rough tanned basil, after scouring, straining, dyeing, and finishing, becomes a roan. It is largely used in the cheaper kinds of bookbinding, having somewhat the appearance of morocco, but is not nearly so durable.

Roasting (*Met.*) The preliminary heating of ores without fusion, whereby oxidation is effected, or certain constituents, such as sulphur, are partially driven off.

Robeson Magnets (*Elect.*) A magnet formed by a thin rod of steel, on the ends of which are fixed steel spheres. The poles of the magnet lie almost exactly at the centres of these spheres.

Rocaille. The name given to the style of art in vogue in the time of Louis XIV. A characteristic feature was the treatment of scrolls and foliage. *Cf.* ROCOCO.

Rocelline (*Chem.*) *See under* NAPHTHYLAMINES.

Rochelle Salt (*Chem.*) *See* TARTRATES.

Roches Moutonnées (*Geol.*) The surfaces over which a glacier has moved for any length of time has usually been moulded by the erosive action of the stone shod base of the ice into a more or less irregular form, with pits and mounds of various sizes and shapes, all smoothed and striated by glacial action. Where these rounded bosses of rock are exposed at the surface they look, at a distance, like scattered sheep. Hence the name.

Rock (*Chem. Tech.*) The solid mixture of stearates of lime obtained in the first stage of the manufacture of stearine.

—— (*Geol.*) The term "rock" in geological descriptions is not restricted to hard stone, such as granite or sandstone, etc., but is applied to any naturally formed deposit, whether hard or soft, which preserves a certain uniform character over a considerable distance. Thus a bed of soft mud or a bank of sand would come under this designation quite as much as a stratum of limestone or a bed of grit.

Rock Crystal (*Min.*) A variety of QUARTZ (*q.v.*)

Rocker (*Elect.*) The support of a brush in a dynamo or electric motor, by means of which the exact position of the brush can be adjusted.

—— (*Engrav.*) A tool somewhat resembling a broad chisel, used in mezzotint engraving for obtaining a series of points or grain on the plate. *See* MEZZOTINT (*under* ENGRAVING).

Rock Forming Minerals (*Geol.*) The chief rock forming minerals are silicates, the principal exceptions being Quartz, Calcite, and some iron ores. The silicates may be classed as follows: (1) Silicates of Alumina, and (*a*) Potash, (*b*) Soda, (*c*) Lime; (*d*) (*a*) and (*b*), or (*b*) and (*c*) respectively, in combination. To this category belong the Felspars and the Felspathoids. The felspars include: (*a*) The potash felspars Orthoclase and Microcline, the former being usually an original constituent of the acid eruptive rocks, and the latter a prominent mineral in the acid gneisses and pegmatites. (*b*) The soda felspar Albite, which is usually of secondary origin, and is not of common occurrence except in the druses of large granite masses. (*c*) The lime felspar Anorthite, which in its normal state is of very rare occurrence. (*d*) The soda lime felspar Oligoclase, which is a common constituent of many Diorite Granites, and of the Gneisses and Pegmatites allied in composition to them. (*e*) The lime soda felspar Labradorite, which, with its varieties, is probably the most widely distributed of all the felspars, and is the common felspar of the basic and of most of the sub-basic eruptive rocks. The Felspathoids include the minerals Leucite and Nepheline, of which the former is common in many post-cretaceous basalts. Allied to the felspars in composition is the light mica, Muscovite, which in many cases is formed out of dynamically metamorphosed potash felspar. This mica is practically indestructible when in small flakes, and hence is found in most sandstones and also in many clays. Some Muscovite is an original mineral of Granites and Elvans. (2) The Ferro-magnesian Silicates. These include (*a*) Olivine, which is a mineral of common occurrence in the basic and the ultrabasic rocks of eruptive origin, and is rare in, or absent entirely from, the gneisses and schists. (*b*) The Pyroxenes, of which there are several species, varying in crystalline characters, and, to a small extent, also in composition. The commonest of the Pyroxenes is Augite, which is present in most basic and ultra-basic eruptive rocks. A less common species is Enstatite, which also occurs in the rocks just mentioned. The minerals classed under (*a*) and (*b*) give rise, through the prolonged action of underground waters, to the important rock Serpentine (*q.v.*) Some Pyroxene is an important constituent in the initial stage of the Scottish Lewisian Gneiss. Another variety (Diopside) is a common secondary mineral in many highly metamorphosed marbles. Augite, under the influence of dynamic metamorphism, may pass into Hornblende. On the other hand, the latter mineral changes into the former under thermo-metamorphic action. (*c*) The Amphiboles. Of these there are many species, distinguished by their crystalline characters or by differences in chemical composition. The commonest is Hornblende, which is an essential constituent of all Diorites, and which occurs also in most Syenites, as well as in the Diorite-Granites. It is a common constituent in most Andesites and Porphyrites (*q.v.*), as well as the majority of Trachytes and Lamprophyres. Hornblende enters largely into the composition of most of the Scottish Lewisian Gneisses, seemingly as a secondary mineral due to the alteration of the original Pyroxene, and is also of common occurrence in the Pegmatites of these Gneisses. Under prolonged dynamic action Hornblende passes into Biotite, so that many Biotite Gneisses were originally Hornblende rocks. Of the remaining Amphiboles the only one that calls for remark is Tremolite, which is a product of the thermo-metamorphism of some magnesian limestones. Biotite, however, is often an original mineral, and is a characteristic mineral of nearly all Granites, Syenites, and Diorites, as well as of their respective gneisses and pegmatites. It is also found in most Trachytes and Andesites, as well as in the Lamprophyres and Porphyrites. Quartz is an essential constituent of the acid eruptive rocks, and of their respective pegmatites and gneisses. In its derivative state it forms sands and sandstones, and is then a characteristic mineral of the terrigenous rocks (*q.v.*) Calcite is the basis of all limestones. Ilmenite (the ferrous titanate) is the chief *original* iron ore of the basic and ultrabasic eruptive rocks.

Rocking Frame (*Eng.*) A hinged or pivoted support for a train of gear wheels, used for actuating the back shaft of a self acting lathe (*q.v.*)

Rock Salt (*Geol.*) Commercial Salt is obtained from three principal sources: (1) By the natural or the artificial evaporation of sea water; (2) by collecting the films of salt left on the surface of deltas where river water is subject to excessive evaporation; and (3) from stratified deposits, such as those which occur in connection with the Keuper Marl (Cheshire), or with the Bunter Marl (Middlesboro'). The term Rock Salt is generally restricted to these last-mentioned stratified deposits. Most Rock Salt appears to have originated in the following manner: During storms large quantities of the spray of sea water are driven inland by the winds, and, in course of time, undergo some desiccation. Hence the atmosphere, more especially in maritime districts, may be said to be loaded with minute particles of salt dust. These salt particles eventually form the nuclei of raindrops, or fog particles, or flakes of snow, and are thus conveyed to the surface of the Earth. Sooner or later the water thus originating finds its way into rivers, and thence, in the ordinary course, back again to the sea, where the cycle commences anew. But in many parts of the world the water of even large rivers may be entirely returned to the clouds by excessive evaporation. The Caspian, the Dead Sea, the Great Salt Lake, the desert region of Central Asia, present good examples of this nature. In all of these the salts carried down in solution by the rivers undergo concentration as evaporation proceeds, and the dissolved matters are eventually left behind in the solid form. As most of the British Salt deposits occur in connection with strata which have certainly been formed under arid conditions, it is natural to conclude that the deposits of Rock Salt which they enclose have been formed by the prolonged evaporation of bodies of river water in a manner similar to that referred to above.

—— (*Min.*) Sodium Chloride; NaCl. Sodium = 39·3, chlorine = 60·7 per cent. Cubic, sometimes in skeleton cubes or hopper shaped crystals; more often massive. Colourless to yellow, red, blue, or purple, the colours being due to impurities. Magnesium and calcium chlorides are usually present as impurities, and cause the salt to be deliquescent. The sulphates of calcium and magnesium are other common impurities. Large deposits of salt occur around Nantwich, in Cheshire; at Droitwich, in Gloucestershire; also in Catalonia and Castile, in Spain; Bex, in Switzerland; and numerous other localities.

Rococo. A debased style of ornament of the times of Louis XIV. and XV. It is an exaggerated style of ROCAILLE (*q.v.*), characterised by confused and meaningless scrolls, shellwork, and foliage. Subsequently the term was used contemptuously to denote heavy and tasteless decoration. *See also* RENAISSANCE (*Architect.*)

Rod (*Build.*) Brickwork (in London) is measured by the rod, which equals 272¼ square feet of reduced work, *i.e.* one brick and a half thick. In practice the ¼ foot is generally ignored, making it 272 square feet.

—— (*Carp. and Join.*) (1) A stick used for measuring. (2) A flat board, carefully planed, on which is constructed a full sized drawing of a piece of work; in most cases the cross section of the work under construction forms the principal drawing, other details being added if necessary. The joiner uses the rod as a working drawing, taking his measurements from it, and also checking the dimensions of the different pieces of the work by direct comparison with those shown on the rod.

Rod Chisel (*Eng.*) A blacksmith's cutting chisel, held by means of a long handle usually consisting of willow twigs or withies.

Rodding (*Foundry*). Supporting the sand forming the upper part of a mould which projects into a cavity by means of rods of iron of suitable length suspended from the flask. This also prevents the projecting sand from being broken away by the fluid metal.

Rodinal (*Photo.*) *See* PARA-AMIDOPHENOL.

Rod, Pole, *or* **Perch.** *See* WEIGHTS AND MEASURES.

Roentgen Rays (*Elect.*) *See* RADIATION.

Rohrflöte (*Music*). A reedy flute. An organ stop of closed pipes, with a hole in the stopper.

Roll (*Plumb.*) A rounded piece of wood used to dress the lead over at the joints on a gutter or flat.

Rolled Bars (*Met.*) Bars of iron or steel of uniform section produced by passing them through a rolling mill.

Rolled Beam, Girder, *etc.* (*Eng.*) Beams or girders made in one piece by rolling mills, instead of being built up of separate parts.

Roller (*Engrav.*) A wooden cylinder covered with leather, used for spreading an acid resisting varnish over the plane surface of a plate that has to be rebitten. *See* ENGRAVING AND ETCHING.

—— (*Music*). A part of the mechanism of an organ. *See* p. 439.

Roller Chain (*Cycles*). *See* CYCLES.

Roller Delivery Motion (*Cotton Spinning*). A motion on a mule for giving out two or three extra inches of yarn during the winding process as the carriage travels inwards.

Roller Feed (*Carp., etc.*) Certain forms of wood working machinery have grooved rollers between which the timber passes. The rotation of these rollers feeds or drives the wood towards the saw or cutter.

Rollers (*Typog.*) Used for inking the forme in the course of printing. They are made of a composition consisting of glue, treacle, glycerine, etc.

Rolling (*Eng.*) The production of bars or plates by the ROLLING MILL (*q.v.*)

Rolling Curves. Pieces of thin wood, metal, card, etc., cut to shape, are used for setting out the teeth of wheels. *See* WHEEL TEETH.

Rolling Friction. The friction between a rotating body and the surface with which it is in contact, when there is no relative movement of the two surfaces at the point of contact. The case of a wheel rolling on a smooth surface is the best example; the friction is much less than the SLIDING FRICTION (*q.v.*)

Rolling Load (*Eng.*) A load or weight which moves along a structure, as in the case of a vehicle passing over a bridge.

Rolling Locker (*Lace Manufac.*) (1) A plain net machine (Heathcote's principle), but the bottoms of the carriages are toothed, and the teeth engage with fluted rollers, which contribute the necessary movement to the carriages. (2) Defines the method of moving the carriages in the description of lace machine bearing that prefix.

Rolling Mills (*Met.*) Sets of iron (or steel) rollers geared together so as to rotate in opposite directions. Bars and plates of iron are formed by passing a mass of iron between the rollers, which are either plain (for plates) or furnished with suitable grooves for the production of bars of any required section. The machinery can be reversed in some cases, so that a bar can be passed through from the opposite side, in order to save the time and labour involved in bringing the metal round to the side from which it was first passed through. The same object is served by having three rollers, when the mill is said to be THREE HIGH, as distinguished from the mill with two rollers, which is termed TWO HIGH. In the three high mill the top and bottom rollers turn in the same direction, the centre one in the opposite direction. The bar is first passed between the lower ones, then passed back between the upper ones (or *vice versâ*). There are three classes of Rolls; PUDDLING ROLLS, which consist of a train of two pairs for blooms, and are often called the Forge Train; MILL ROLLS, which produce finished merchant iron from billets, and are generally three high rolls; and PLATE MILL ROLLS, specially intended for rolling boiler and other plates. Sheet mills are similar, but for lighter work.

Roll Moulding (*Architect.*) (1) A round moulding or bowtell (*q.v.*) (2) A round moulding with a slightly projecting fillet. (3) A moulding formed of two half rounds, the upper one projecting slightly in front of the lower. The last form is more commonly known as a scroll moulding (*q.v.*), and is characteristic of Decorated Gothic architecture. A roll moulding with a well defined fillet is known as a "roll and fillet" moulding.

Rolls (*Bind.*) Tools used in finishing. A roll consists of a small brass wheel fixed to a handle, the periphery of the wheel being engraved with some design.

—— (*Met.*) *See* ROLLING MILLS.

Roman (*Typog.*) The ordinary upright letter used in printing, as distinguished from *italic* and fancy type. Numerals expressed by letters as distinguished from those expressed by Arabic characters. *See* NUMERALS.

Roman Architecture. The style of architecture which obtained in the Roman Empire during the first four centuries of the Christian era. In this style the trabeated construction of the Greeks is combined with the use of the semicircular arch, dome, and vault. The three orders used by the Greeks were adopted, with various modifications, by the Romans; and variations of the Doric and Corinthian orders, known as the Tuscan and Composite orders respectively, were also used by them. The orders are, however, used more as a decoration than as an essential part of the construction. Pedestals are used to increase the height of the order, and the various orders are superimposed over each other, the simplest and most sturdy being always placed below the slender and more ornate orders. The peripteral form of temple of the Greeks was not extensively used by the Romans, the pseudo peripteral taking its place. Roman mouldings are usually richly carved, but they lack the refinement characteristic of Greek work. *See* GREEK ARCHITECTURE *and* ARCHITECTURE, ORDERS OF.

Roman Cement. A quick setting cement used for plastering the outside of walls, when required to be painted soon after the plastering is finished. *See* CEMENTS.

Roman Corinthian Order. *See* ARCHITECTURE, ORDERS OF.

Roman Doric Order. *See* ARCHITECTURE, ORDERS OF.

Romanesque Architecture. The architecture of Western Europe, which was developed after the decline of Roman architecture, and from which Gothic architecture was developed, is known as Romanesque. Romanesque architecture in England is divided into two periods—Anglo-Saxon and Norman (*q.v.*)

Roman Ionic Order. *See* ARCHITECTURE, ORDERS OF.

Röntgen Rays (*Phys.*) *See* RADIATION AND RADIO-ACTIVITY.

Rood. *See* WEIGHTS AND MEASURES.

Rood Screen (*Architect.*) The screen separating the chancel from the nave in a Gothic church. The platform which is frequently found above the rood screen, and known as the rood loft or jubé (*q.v.*), supported the rood or crucifix.

Roof (*Mining*). The upper or overhead surface of a working.

Roofs (*Build.*) Roofs vary greatly, both in form and in the materials employed in their construction. In countries where there is little rainfall, flat or very low pitched roofs are often found, and projecting eaves are added to afford shade. With increasing rainfall and the occurrence of snow the angle of inclination increases. The nature of the covering material varies with locality, climate, means of transit, the dimensions of the structure, and other factors. Among the chief natural materials now used may be enumerated THATCH in various forms, WOOD, SLATES, and STONE, which possesses a marked parallel cleavage; among manufactured materials, TILES, SHEET IRON, LEAD and ZINC, GLASS, and flexible materials which have been rendered waterproof, such as FELT, CANVAS, PAPER, CARDBOARD, and various patented materials. The structure which supports the roofing material takes many forms, of which a few only can be dealt with here The simplest form is the LEAN-TO ROOF (fig. 1). A is a RAFTER supported by WALL PLATES B and C, the former resting directly on the top of one wall, the latter being carried on corbels or by a ledge or offset. This form is suitable for spans of 8 or 10 ft. Fig. 2 shows a simple Couple Roof for spans of 10 or 12 ft.; the rafters A, A rest on wall plates B, B at their lower ends, and abut against a RIDGE PIECE D at the top. If the span exceed 12 ft., the outward thrust of the rafters may be counteracted by a tie or COLLAR E (fig. 3). When the tie extends across between the lower extremities of the rafters, the arrangement is termed a COUPLE CLOSE. The ties may serve to support

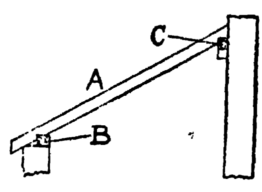


FIG. 1.

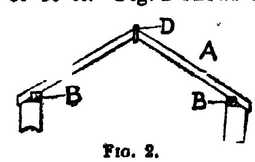


FIG. 2.

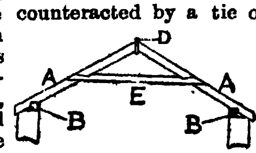


FIG. 3.

a ceiling, *i.e.* they form CEILING JOISTS. A roof of this pattern may be used for spans up to 16 ft. A further modification is shown in fig. 4. Here the rafters A, A rest on POLE PLATES F, supported by the TIE BEAM G. The rafters are further supported by STRUTS H, H, which abut against a piece K, termed a STRAINING SILL. For spans of 20 ft. or more a KING POST TRUSS (fig. 5) may be used. The

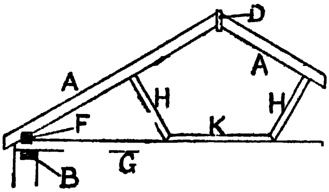


FIG. 4.

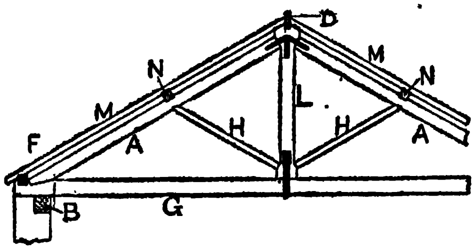


FIG. 5.

PRINCIPAL RAFTERS A, A are attached at their lower ends to the TIE BEAM G, the joint being secured if necessary by an iron strap passing round both rafter and tie beam. At the upper end each rafter is tenoned into the vertical KING POST. Iron plates, shown in black, strengthen these joints; at the lower end a strap passes under the tie beam, and is tightened up by wedges, forming a gib and cottar, and passing through the king post. The COMMON RAFTERS M, M are supported by PURLINS N, N, which are horizontal timbers placed parallel to the ridge and supported in turn by the principal rafters. In the construction of still larger wooden roofs a QUEEN POST TRUSS (fig. 6) is used.

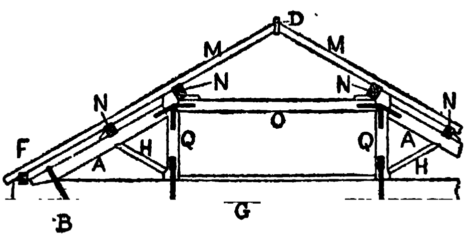


FIG. 6.

The letters correspond to those employed in fig. 5, with the addition of certain members; these are two QUEEN POSTS Q, Q; a STRAINING BEAM O; a straining sill between the lower extremities of the queen posts, and struts H, H. Iron bands and plates (shown in black) are used to strengthen the principal joints. The form of a roof may be modified to enable the roof space to be utilised as a room: one of the ways of doing this is to employ a MANSARD ROOF, shown in outline in fig. 7.

When two roofs intersect, as when the surface slopes upward from the ends as well as the sides (instead of ending in a gable), a HIPPED ROOF is formed. The rafter which runs from the intersection of the wall plates to the ridge is termed a HIP RAFTER; those which run from the wall plate and terminate against the hip rafter are termed JACK RAFTERS. A special device is often used in the larger roofs to strengthen the roof at the angles of the wall; this is shown in fig. 8. B, B are two wall plates, halved together at the angle, and connected by a member D. To the centre of this the DRAGON BEAM C is attached by a tusk tenon; at its other end it is notched to the wall-plates. In certain cases, such as churches and large mediæval halls, no ceiling is used, and the timbers of the roof are treated in a decorative manner. In such cases the HAMMER BEAM TRUSS is frequently used, the principal rafters being supported as in fig. 9. A corbel C supports a WALL PIECE W, from the top of which projects a HAMMER BEAM H, supported by a strut S. Above the hammer beam springs the PRINCIPAL RAFTER A. The hammer beam thus appears to be the end of a tie beam, of which the central portion has been removed. The largest roofs are now constructed of iron, which offers many advantages. A good tension joint, always difficult in woodwork, can easily be secured; tie beams may be replaced by slender tie rods, and struts, principals, etc., by rolled T iron or channel iron, much less cumbersome than the massive wooden members which they replace. Great variety of form is given to iron roofs, two simple forms being shown in figs. 9 and 10. Joints are made by flat plates, eyes, etc., riveted, or, preferably, bolted together.


FIG. 7.

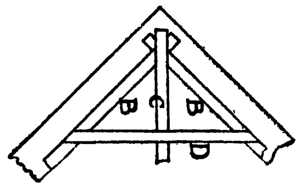


FIG. 8.

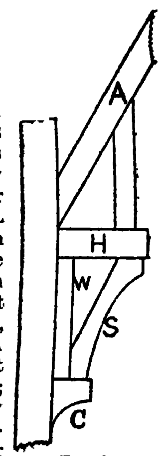


FIG. 9.

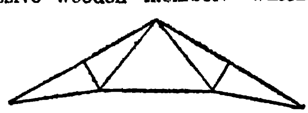


FIG. 10.

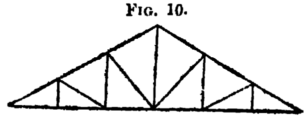
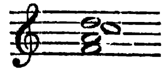


FIG. 11.

Root (*Music*). The note on which a chord is built, *i.e.* the bass note of a chord in its original position. The "Day" Theory traces all chords to the three roots, Tonic, Dominant, and Supertonic; but this theory is by no means universally accepted. For instance, the chord



in the key of C would, according to the "Day" Theory, have the root G, and be called the third inversion of the Dominant 11th. Another theorist looks upon F as the root, and speaks of it as the Added 6th; whilst yet another looks upon D as the root, and calls it the first inversion of a 7th. The idea of tracing chords from roots seems to have originated with Rameau in the latter part of the seventeenth century.

Rope Crane (*Eng.*) A form of overhead crane driven by ROPE GEARING (*q.v.*)

Rope Gearing (*Eng.*) Power can be transmitted long distances by means of ropes, which serve as belting. The ropes are allowed to hang somewhat loosely, and as the tension in them is small, they must run at a high speed. If the machinery to which the power is transmitted is not stationary, some arrangements must be made for "taking up the slack." This is usually managed by leading the rope over guide pulleys, which can be moved up or down as required, so that the necessary tension is maintained.

Ropes. Ropes are made of hemp, manilla, cotton, or iron or steel wire. The size of a rope is its circumference in inches; thus a six inch rope is one rather under 2 in. in diameter.

Rope Wheel. A pulley with a V-shaped groove, often with corrugations along the inside of the channel, which is used when motion has to be transmitted from the rope to the wheel, or *vice versâ.*

Rosaceæ (*Botany*). A large and important order of *Dicotyledons.* Many of the plants are of economic value (Rose, Apple, Plum, etc.), while others are cultivated as garden plants (Rose, Spiræa, Geum, etc.)

Rosalia (*Music*). The device of repeating a musical figure, transposing it one note higher at each repetition. This device should never be continued more than three times in succession.

Rosaniline (*Chem.*)

$$HC \begin{cases} \overset{(1)}{-} C_6H_3 \begin{cases} CH_3(3) \\ NH_2(4) \end{cases} \\ \overset{(1)}{-} C_6H_4NH_2(4) \\ \overset{(1)}{-} C_6H_4NH_2(4) \end{cases}$$

Leucaniline, the leuco compound of rosaniline. (Paratriamidodiphenylmetatolyl methane.)

$$HO.C \begin{cases} C_6H_3CH_3NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \end{cases}$$

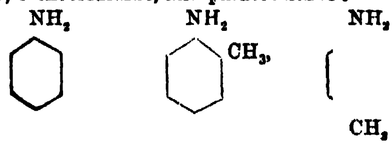
Colour base of rosaniline (Paratriamidodiphenylmetalolyl carbinol.)

$$C \begin{cases} C_6H_3CH_3NH_2 \\ C_6H_4NH_2 \\ C_6H_4.NH_2Cl \end{cases}$$

Rosaniline hydrochloride, commonly called rosaniline. Rosaniline itself would be

$$C \begin{cases} C_6H_3CH_3NH_2 \\ C_6H_4NH_2 \\ C_6H_4:NH \end{cases}$$

and is only known in the form of its salts, of which the hydrochloride and acetate too are used as a dye under the names rosaniline, magenta, and fuchsine. These salts form lustrous greenish octahedral crystals, slightly soluble in cold water, readily soluble in hot water or in alcohol, the acetate being more soluble than the hydrochloride. The solution is red. On adding much hydrochloric acid to the solution it turns yellow, owing to the formation of an acid salt. It dyes silk and wool bluish red, cotton mordanted with tannin and tartar emetic the same. When boiled with caustic soda solution the colour base is formed, and crystallises in white leaflets on cooling. Magenta forms a colourless compound with sulphurous acid, which gives other dyes when aldehydes are added to it (Test for aldehydes). The constitution is settled in the same way as that of Pararosaniline (*q.v.*) Rosaniline is prepared by the oxidation of a mixture in molecular proportions of aniline, orthotoluidine, and paratoluidine:



The oxidising agent is nitrobenzene in presence of iron and hydrochloric acid, and its mode of action is that described under pararosaniline (*q.v.*) That the nitrobenzene does not act directly seems to be shown by the fact that if chlornitrobenzene is used, no chlorine substituted rosaniline is formed. The action is carried out as under pararosaniline. A number of important dyes are rosaniline derivatives. *Acid magenta* is the sodium salt of rosaniline trisulphonic acid. *Hoffmann's violet* is triethylrosaniline, obtained by heating rosaniline, ethyl iodide, and alcohol together. *Iodine green* is pentamethylrosaniline, obtained by heating rosaniline, methyl iodide, and methyl alcohol together. *Aniline blue:* When phenyl groups are introduced into the rosaniline molecule the colour varies from violet to blue as the number of groups introduced increases from one to three. Aniline blue itself is triphenylrosaniline, one phenyl group entering each amido group. It is usually met with as the hydrochloride which forms brilliant green crystals insoluble in water, sparingly soluble in alcohol; the acetate readily dissolves in alcohol (spirit soluble blue). By the action of concentrated sulphuric acid one to four sulphonic acid groups may be introduced forming soluble aniline blues, which are much used as dyes. Aniline blue is made by heating rosaniline (colour base) with a large excess of aniline and some benzoic acid to the boiling point of aniline for some hours. On treating the product with concentrated hydrochloric acid the hydrochloride separates out.

Rose (*Botany*). *Rosa,* a genus of the order *Rosaceæ.* From *R. centifolia* is obtained the volatile oil known under the name of ATTAR or OTTO OF ROSES. This oil occurs in the petals of the flower. ROSEWATER is also prepared from the petals.

—— *or* **Rosette** (*Architect.*) The flower used in the centre of each of the concave faces of the Abacus of the Corinthian capital is known as a rose. A form of rose is also used as a repeating ornament in the Norman "Rose moulding," and the "Tudor rose" is an ornament freely used in Perpendicular Gothic architecture.

Rose Bengale. *See* DYES AND DYEING.

Rose Bit. A boring tool or bit whose shank or body is equal in diameter to the hole to be drilled, the cutting edges being formed on the end of the tool only. These cutting edges are usually in the form of radial teeth cut on the flat or rounded end of the bit. It is used for making a hole truly cylindrical after it has been drilled out nearly to size by an ordinary drill.

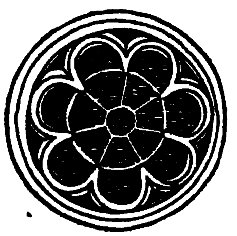
Rose Madder (*Paint.*) One of the lightest coloured of the madder lakes, but a little darker than pink madder. It is prepared from madder root and placed in a filter press, from which a clear liquor is obtained. On the addition (which should be gradual) of sodium carbonate, the colour is precipitated. *See* MADDER. Much of the commercial rose madder is made from alizarin. *See* LAKES.

Rosemary (*Botany*). The essential oil distilled from the inflorescence *Rosmarinus officinalis* (order, *Labiatæ*).

Rose Quartz (*Min.*) A variety of QUARTZ (*q.v.*) of a rose colour.

Rosette Copper (*Met.*) Copper obtained in thin masses by throwing cold water on the surface of the fluid metal.

Rose Window (*Architect.*) The richly traceried circular windows peculiar to the Decorated period of Gothic architecture are known as Rose Windows. These windows were developed from the wheel windows of the Early English period, in which the arrangement of the mullions resembles that of the spokes in a wheel. Rose windows are also known as Catherine wheel windows and Marigold windows.



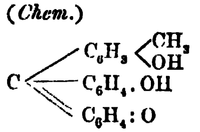
ROSE WINDOW.

Rosewood. *See* WOODS.

Rosin. *See* RESIN.

Rosin Oil (*Dec., etc.*) A heavy oil obtained by the dry distillation of rosin. It is mixed with lime for producing rosin greases, and used in printer's ink and sometimes as a paint oil. It is, however, not suitable for the latter purpose, as although it hardens when first exposed, it is very apt to afterward become soft. Three qualities of rosin oil are recognised, *viz.* "hard," "medium," and "soft." Specific gravity varies from 0·980 to 0·990, but heavier oils are made.

Rosolic Acid (*Chem.*)



Crystallises in red plates with green reflex; very slightly soluble in water; soluble in alcohol with orange-red colour; soluble in alkalis with red colour. It gives a leuco-compound on reduction. Heated with water at 240°, it forms phenol and dihydroxyphenyltolylketone, $C_6H_4OH.CO.C_6H_3CH_3OH$. It is formed from rosaniline (*q.v.*) by diazotising it and boiling the hexazo-compound with water; it is also formed by heating together phenol, cresol, arsenic acid, and sulphuric acid. A similar compound, called PARAROSOLIC ACID, or Aurin, is obtained in a similar way from pararosaniline. These compounds are only used in colouring varnishes and lacquers.

Rostrum (*Architect.*) A platform or other elevated place from which a speaker addresses an audience.

Rot. *See* WOODS.

Rotary Converter (*Elect. Eng.*) A machine by which a continuous current is changed into an alternating one, or *vice versâ*; both currents traverse the same armature winding. It is essentially an ordinary continuous current machine, but is provided, in addition to a commutator, with slip rings connected to definite points on the winding.

Rotary Cutter (*Carp.*) A number of separate cutters analogous to plane irons, mounted in a central block (termed an ADZE BLOCK) which rotates at a high speed; used for planing, moulding, etc., on a large scale.

—— (*Eng.*) A rapidly revolving wheel of hardened and tempered steel, furnished with teeth of suitable form; used in milling machines, gear cutting, etc.

Rotary Engines (*Eng.*) In many of the early forms of steam engine the chief moving parts had rotary, instead of reciprocating, motion. None of these forms were really successful, but their objects have now been attained in the STEAM TURBINE (*q.v.*), which, however, depends upon principles different from those of the early rotary engines. *See also* STEAM ENGINE.

Rotary Furnace (*Met.*) *See* REVOLVING FURNACE *and* PERNOT'S FURNACE.

Rotary-Machine. *See* TYPOGRAPHY.

Rotary Pumps (*Eng.*) CENTRIFUGAL PUMPS (*q.v.*)

Rotary Strainer (*Paper Manufac.*) An apparatus used for removing small knotty pieces of material from beaten pulp.

Rotary Transformer (*Elect. Eng.*) *See* ROTARY CONVERTER.

Rotation (*Astron.*) The motion of a body round a central axis, like the earth round its axis.

Rotation of the Plane of Polarisation (*Light*). *See* POLARISATION.

Rotator (*Met.*) A REVOLVING FURNACE (*q.v.*)

Rotatory Power (*Chem.*) *See* MOLECULAR ROTATORY POWER.

Rotor (*Elect.*) The revolving portion of an alternating or polyphase current motor.

Rottenstone (*Geol.*) Certain limestones contain a large proportion of silica, originally opaline in character, and mostly of organic origin. When such limestones are acted upon by waters containing carbonic acid or the humus acids, the lime is removed and the finely divided silica is left as a powder known as Rottenstone. Used for polishing household articles of metal.

Rotunda (*Architect.*) A building which is circular in plan, both inside and outside. The Pantheon at Rome and the Albert Hall in London are examples.

Rouge. A finely ground polishing powder of red colour, composed of ferric oxide, usually prepared from one of the salts of iron (*e.g.* the sulphate or oxalate). The term Rouge is also applied to various mixtures which are used as polishing powders and possess the same tint; *e.g.* a mixture of powdered TALC (*q.v.*) with the flowers of the SAFFLOWER (*q.v.*)

Rough Brackets (*Carp. and Join.*) (1) The wood brackets behind a plaster cornice. (2) The triangular pieces fixed to the carriages of stairs.

Rough Cast (*Build.*) A style of plastering the outside of half timber houses, gravel being mixed with or thrown on the wet plaster, to which it adheres.

Rough Coat (*Foundry*). The first layer of loam applied to a core bar, etc., in building up a core or a loam pattern.

Rough Cut (*Eng.*) (1) Applied to the coarsest toothed files. (2) Taking off a quantity of material to bring it approximately to shape or to remove skin or scale from the surface.

Roughing (*Linen Manufac.*) The first process of hackling. It consists of drawing the rough flax in handfuls over coarse pins set in a block of wood, to comb out all short and twisted fibres and split up all parcels of fibres that may be sticking together. Also termed "Rough hackling."

Roughing Hole (*Met.*) A basin-shaped cavity in the ground into which the slag from a blast furnace is run and allowed to cool before removing to the cinder tip. It is used as an alternative to cinder tubs. A conical steel pin is placed in the middle of the hole, by which to pick up the slag "oyster" when cool.

Roughing Out (*Eng.*) Shaping a piece of material in an approximate manner: applied especially to the preliminary stages in forging.

Roughing Rolls (*Eng.*) A rolling mill used to shape a bloom of puddled iron into a bar preparatory to the exact rolling which produces the final form. *See* ROLLING MILLS.

Rough Measurements (*Eng., etc.*) Approximate measurements given in the case of castings, forgings, etc. They are always larger than the proper dimensions of the finished object, thus allowing for machining and fitting.

Rough Plate (*Glass Manufac.*) *See* PLATE GLASS.

Roulette (*Engrav.*) A tool consisting of a small wheel or disc of tempered steel attached to a handle, the edge of the disc being furnished with sharp teeth. Used in engraving for imparting tone or tint to a metal plate, or as an adjunct in etching.

—— (*Math.*) A plane curve traced out by a point in a curve, or in the plane surface enclosed by the curve, which rolls (without slipping) on another curve.

Round (*Music*). A species of infinite canon in which the performers begin at regular intervals and sing the same music, coming "round" to the beginning again after reaching the end. A round written out in full instead of in score was called a "catch," but the term is also applied to a round having humorous effects, a well known example being, "Would you know my Celia's charms?"

Roundel (*Her.*) *See* ROUNDLET.

Rounding (*Bind.*) Shaping the back of a book previous to backing and binding. This is effected by holding the book in a certain position and striking the back with a hammer, the book being turned over from time to time until the back is a suitable shape.

—— (*Leather Manufac.*) Hides either previous to tanning or after tanning and before finishing are cut up into the butt or back, the shoulder, and the belly. This process is termed rounding.

Roundlet *or* **Roundel** (*Her.*) Small round discs of frequent occurrence as charges. The various tinctures give them distinctive names. If *or*, they are blazoned "bezants"; *argent*, "plates"; *azure*, "heurtes"; *gules*, "Torteaux"; *vert*, "pommes"; *purpure*, "Golpes"; *sable*, "pellets"; *tenné*, "oranges"; *sanguine*, "guzes." The last two are seldom seen. The Fountain is represented divided horizontally by wavy lines, *i.e.* barry wavy of six, argent and azure.

Round Nose (*Eng., etc.*) A term applied to various tools with a cutting edge which is rounded, as seen on plan.

Round Plane (*Carp.*) *See* HOLLOWS *and* ROUNDS.

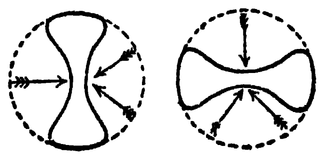
Router (*Carp.*) A cutting tool fixed in a stock or body; the edge projects some distance below the sole or lower surface of the stock, and is used for cutting the bottoms of grooves and sunk surfaces in woodwork.

Rove *or* **Roving** (*Textile Manufac.*) The term applied to the sliver or flat tape after it is finally drawn out and has received a slight twist in the machine called the roving frame, preparatory to spinning.

—— (*Cotton Spinning*). The final strand or coarse thread, slightly twisted, which is produced on the roving frame for the purpose of spinning into a thread on the ring frame or mule. Sometimes applied as a general term to the productions of all fly frames.

Rowel (*Her.*) The end of a spur formed like a star or wheel; replaced the earlier "pryck spur" about 1320.

Row Tube. This is a patented form of steam heating tube, which, when formed into coils or batteries, gives much better results than plain copper tubing. They are also used for condensing waste steam. An ordinary copper tube is indented alternately at the sides and top and bottom to yield the following section:



1 2

The steam is thus baffled, and a much greater heating or cooling surface rendered serviceable.

Royal (*Paper Trade*) Printing paper 20 × 25 in. Writing paper 19 × 24 in.

Royal Academy. *See* ACADEMY, ROYAL.

Royal Cord (*Silk Manufac.*) *See* OTTOMAN.

Ru (*Chem.*) The symbol of RUTHENIUM (*q.v.*)

Rubato (*Music*). Robbed. In order to enhance the expression of a passage some notes of a bar are performed not in strict time, *i.e.* if part of a bar is faster than the correct *tempo*, the remainder of the bar must be slower, as the length of the whole bar must correspond with other bars. Mr. Fuller Maitland says, in *The Dictionary of Music and Musicians*: "Tempo rubato is allowable in the works of all the modern 'romantic' masters, from Weber downwards, with the exception of Mendelssohn. In the case of the older masters it is entirely and unconditionally inadmissible, and it may be doubted whether it should be introduced in Beethoven."

Rubber (*Build.*) *See* CUTTER.

—— (*Joinery, etc.*) An abrading surface, such as sandpaper, wrapped round or attached to a block of wood, which serves as a holder. Used for smoothing wood ready for varnishing, polishing, etc.

Rubber (Indiarubber *or* **Caoutchouc).** An elastic gum or resin derived from a great variety of trees, vines, and shrubs, most of which grow in the Torrid Zone. The *latex* or milk is obtained by making incisions through the bark, but not as far as the wood. In the case of some vines and shrubs short lengths are chopped up and the rubber extracted by means of pounding and soaking in hot water. There are over two hundred varieties of rubber on the market—not because of any great difference in the rubber, as rubber, but owing to the method of preparation, impurities present, geographical and botanical distinctions. The valley of the Amazon, consisting of hundreds of thousands of square miles of forests in Brazil, Bolivia, and Peru, produces annually about thirty thousand tons of rubber, which is known as PARA (the name being derived from the city of Para, from which the bulk of it was originally exported). This rubber is derived from the *Hevea brasiliensis*. South America also produces other sorts of rubber, from the *Castilloa elastica*, which is known as CENTRALS; and from the Atlantic States of Brazil are obtained grades of rubber known as CEARA, PERNAMBUCO, MANGABEIRA. Africa comes next to South America as a rubber producing country, and the bulk of the rubber produced is from the *Landolphia*, a vine or creeper. Other sorts are obtained from trees and shrubs, the latter including a plant whose roots, growing to considerable distances underground, yield a rubber of fair value. Other portions of the world produce rubber also, but Africa and South America are the principal sources. At the present time vigorous efforts are being made to cultivate rubber trees in Ceylon, India, Straits Settlements, Mexico, etc., and with great success.

The *latex* as it issues from the tree resembles cream. The natives coagulate the rubber by different methods, the best known being the smoking process. The semi-liquid rubber is collected in a pan, and a broad stick thrust into it. A coating of the thick liquid covers this "paddle," which is then withdrawn and revolved over a smoky open fire until evaporation of the water contents of the latex takes place. As soon as one film is dry the process is repeated until the rubber forms a solid ball of considerable size. The best method, however, is that in use on cultivated plantations of rubber trees, and consists of washing the rubber, after it has coagulated, pressing into sheets, and drying thoroughly before sending it away.

It is necessary to understand the history of the rubber industry in order to appreciate the difficulties and peculiarities of the trade. The first indication in literature of rubber occurs in a Spanish history of the Indies, published in 1536, in which a game of ball is mentioned, the ball being made of a different substance than "that used by Christians." A Jesuit priest later describes this ball as of solid matter, but extremely porous and light, and notes its properties of rebounding from the ground to a much greater height than the ball in use in Europe. About 1600 another Spanish author comments on this ball as being made from a "gum," the product of a tree which, when the bark is cut, yields a milk. In 1615 still another Spanish author mentions the use of these balls, and calls the tree that furnishes the gum "the tree of Ule." He states also that the conquering Spaniards coated their hempen cloaks with this "milk"; but while the cloaks were thus rendered waterproof, light and heat soon destroyed the coating. A little before this a few samples of this elastic gum were received in Europe, but so rare were these that they sold at a guinea an ounce. Nothing more is recorded for over a century. In 1730 the exact form of the earth was one of the interesting topics of the day, and the Paris Academy sent out two expeditions, one of which was under the direction of an eminent naturalist named Lacondamine. In 1736 this scientist sent to the Paris Academy a resinous mass, of a blackish colour, which he calls by the native name of "cahuchu," afterwards spelled "caoutchouc."[1]

The attention of other botanists and explorers was attracted to this peculiar product, and search for it was made in other parts of the world, with the result that "gums" or "resins" with similar properties were found in Guiana, Prince of Wales Island, Assam, and Madagascar.

So much for the discovery of the crude material. Meantime various scientists were experimenting in order to discover some method of employing it in the manufacture of articles for which its properties were obviously suitable. In 1768 it was known that pure ether, spirits of turpentine, and a substance known as "Dippel's animal oil" would soften and dissolve, to a greater or less extent, this elastic gum. Ether was, of course, too expensive for commercial purposes, and the commercial spirits of turpentine varied very greatly at this time and for long afterwards. Dippel's animal oil was a thick, viscid, brown oil with an unpleasant smell, prepared by the destructive distillation of bones. By using one or the other of these solvents, however, small tubes and suchlike were made in an experimental manner. Priestly, the well known English chemist, in 1770, was the first to call the attention of the world to at least one of the properties of caoutchouc, namely, its power of effacing pencil marks, and it was this use that gave caoutchouc its popular and now general name of indiarubber, *i.e.* a substance from India used as a rubber. By 1775 the use of rubber for this purpose was well established, and small squares of it could be obtained at most stationers' shops. Although many other chemists, both in this country and in France, were studying the subject, very little advance was made up to 1820. Indeed, all that was accomplished was the discovery of a slightly better method of making articles out of the crude rubber. The "bottles" of rubber (as they were then called, owing to their shape) were cut up into thin, narrow strips of the most convenient size. These were immersed in ether for a short time until they became soft and swollen. The strips were then wrapped around a shape or mandrel of suitable size, and a bandage twisted round so as to press the rubber together. As the ether evaporated the surfaces at the joins became amalgamated. In this way a number of articles were made which proved useful enough, but, of course, were clumsy and subject to many disadvantages. They became tacky in hot, and cracked in cold weather, and the rubber quickly deteriorated. Many attempts were also made to waterproof cloth by means of solutions of rubber; but while some of these efforts doubtless proved successful for special purposes of limited scope, none proved of commercial importance. The pioneer in rubber who advanced the industry most in England

[1] The pronunciation of "caoutchouc" has given rise to much embarrassment as well as argument. There are at least six recognised pronunciations used in the trade. Webster states that the proper pronunciation is *koo-chook*. This is probably the worst rendering. Two others only need be mentioned: *cow-chook*, and, to our mind best of all, as resembling the native name, *ca-oot-chew*.

was Thomas Hancock. In 1820 he took out his first patent in rubber, but finding that with the crude methods then in use it would be impossible ever to bring rubber into extended use, he set about investigating the subject. He discovered that if the rubber as imported was subjected to heavy pressure and friction, such as would take place by its repeated passage between rotatory cylinders, it became a homogeneous mass. The machine he invented for this purpose was first called a PICKLE, then MASTICATOR, the latter being the name now in use. Rubber, however, in its natural or cleaned condition becomes sticky in hot weather and cracks in cold. Further experiments were required in order to discover some method of freeing it from these defects. The following is a brief list of the important discoveries:

WATERPROOFING.—MACINTOSH in 1823 discovered that coal tar naphtha would dissolve rubber, and with this solution he coated fabrics. The solvent evaporating left a thin film of rubber, thus rendering it air and waterproof. This is now known as PROOFING, and the garments as mackintoshes.

VULCANISATION. CURING.—Despite the progress being made in the use of rubber it had still the grave disadvantage of being influenced by change of temperatures. The discovery of a process for rendering rubber indifferent even to extreme heat or cold was made independently by Charles Goodyear in America and Thomas Hancock in England. Vulcanisation consists of the mechanical mixture of dry rubber with sulphur, and the exposure of the compound to heat (from 120° to 136° C. for varying lengths of time, from twenty minutes to three hours). The theory of vulcanisation as to whether a chemical change takes place or whether the action is catalytic is still in dispute. The effect of vulcanisation is to change the rubber from a plastic mass, which becomes sticky on heating and brittle on exposure to low temperatures, into a substance elastic, but not plastic, unaltered by moderate temperatures and much less liable to deteriorate by age. The COLD CURE is another method of vulcanisation which is applied to thin articles, and consists of mixing chloride of sulphur in bisulphide of carbon and DIPPING the rubber in the mixture. The effect produced is similar to vulcanisation, *but only the surface of the article is changed. See* VULCANISING INGREDIENTS, FILLERS, *and* SUBSTITUTES, *below*.

EBONITE, HARD RUBBER, VULCANITE.—Nelson Goodyear discovered that if rubber was mixed with a very large percentage of sulphur and exposed to a high temperature for a considerable time, the result was a substance altogether different in properties from rubber. This ebonite is akin to whalebone in some of its properties, like ivory in others. Great modifications are possible, and depend upon the amount of sulphur and the time the substances are subjected to heat. There is, therefore, no true dividing line between a soft rubber and a hard rubber, nor is it possible to define a hard rubber. It may be made as flexible as whalebone or as stiff and unyielding as ivory, and the gradations between are endless.

MOULDING.—Hancock in 1846 put into practice the system of moulding articles in rubber, an invention of the utmost utility. This method of manufacture consists in filling a mould or shape with the sulphur and rubber mixture, applying pressure to the parts of the mould and vulcanising. The resulting product reproduces in permanent form the most delicate chasings and decorations both in soft rubber and in ebonite, a good example of the latter being the fountain pens so common to-day.

THE MANUFACTURE OF RUBBER ARTICLES.—A brief outline of the methods used in manufacture will give the reader a better knowledge of the subject than further details. The crude rubber is first put through the WASHING MILL. This consists of two heavy fluted rollers revolving at different speeds. The rubber is formed into a thin corrugated sheet by its frequent passage between these rolls, and thoroughly washed by a stream of water playing upon it during the process. In this state it is taken to the DRYING ROOM, where it is allowed to remain until every trace of moisture is removed. At the present time this slow method is done away with in some factories, and the rubber is put into a hot chamber or dried *in vacuo*. The dried sheets are then put through the MASTICATOR or MILL until it becomes a softened homogeneous mass. It is then put on to the MIXING MILL, where two rolls running at different speeds very quickly force into the rubber the sulphur and such other ingredients as may be thought best to add to the mixture. *See* FILLERS, *below*. The mixed rubber is then put into moulds and vulcanised, or put through the CALENDER, which is simply another form of mixing mill, and is used to form the mixed rubber into sheets of the most convenient size and thickness for subsequent use. The calender is also employed when the mixed rubber is to be used with a fabric. Both the fabric and rubber are passed through the rolls, and by means of great pressure the rubber is forced into the interstices of the fabric. Some calenders have smooth rolls, others have decorative lines engraved upon them, etc.

After the rubber is got into the desired form it is vulcanised, that is, subjected to heat. The simplest form of vulcaniser is that used in the manufacture of rubber stamps; this is simply a letter copying press, the bottom plate of which is heated by a gas jet.

HOLLOW WORK.—This merits special reference because of the almost universal use of articles manufactured by this method, *i.e.* bulbs, balls, dolls, etc. From the sheeted mixture of rubber and sulphur segments are stamped out of suitable size. These segments are fitted together in a mould, and a little carbonate of ammonia placed inside. The mould is then closed and put in the vulcaniser. As soon as the heat reaches the carbonate of ammonia it volatilises into a gas, which forces the rubber against the sides of the mould into every crevice, and retains it there until it assumes a permanent form.

CUT SHEET WORK.—Many articles of rubber are produced in a simple manner from sheets. Before vulcanisation the freshly cut edges of rubber have the property of great adhesiveness. In the formation of articles from sheet, therefore, as soon as the sheet is cut into convenient size, the edges are put together and lightly pressed or tapped, when they adhere, or a little solution is applied with the same result.

VULCANISING INGREDIENTS, FILLERS, AND SUBSTITUTES.—While sulphur is the principal substance used to bring about the change in rubber known as vulcanisation, there are other substances containing sulphur which bring about the same result. The two most used are golden sulphuret of antimony and sulphide of zinc.

FILLERS is the name applied to a great number of substances mixed with rubber for various purposes, and as this portion of the subject is little understood, the following notes may show that mere adulteration is not the principal object aimed at.

The ELASTICITY of soft rubber goods is often increased by the addition of vermilion and slaked lime, or by admixture with asphaltum or colophony. The RESISTANCE TO PRESSURE is increased to a more or less degree by the addition to the mixing of zinc oxide, calcined magnesia, asphaltum, or chalk. The MECHANICAL STRENGTH of soft rubber is improved by the addition of such mineral substances as magnesia, litharge, chalk, lime, zinc oxide, and in some cases by asphaltum, and, it is said, glycerine. The INSULATING PROPERTIES of pure rubber are not so great as a mixture of rubber and paraffin wax, and the addition to rubber of zinc oxide, lime, magnesia, and white and brown substitutes in comparatively small quantities also improves its dielectric properties. The RESISTANCE TO ACIDS is increased more or less by the addition of organic compounds. The ACTION OF OILS upon rubber is lessened by the addition of litharge and zinc oxide to the mixing. Rubber by itself is not necessarily the best material for a particular purpose; in many cases it is the worst, or at least one of the worst. The use of rubber is only the means to an end, and the whole art of manufacture is to arrive at the best means at the smallest expense. To illustrate the point take the case of rubber belting. Apart altogether from the expense of using pure rubber, it would be inadvisable to do so, since the elasticity of pure rubber subjected to the constant strain of the pulleys would result in the separation of the rubber from the fabric. In consequence the elasticity has to be reduced and the mechanical strength increased. Now all inorganic (mineral) substances in a mixing reduce the elasticity of rubber, and, referring to the above, it will be seen that the addition of such mineral substances as zinc oxide, litharge, magnesia, etc., improves the mechanical strength of rubber. It is obvious, therefore, that in a belting the use of pure rubber would not only be more expensive, but would be vastly less efficient than a mixing containing rubber plus something else.

SUBSTITUTES for rubber are very numerous, but few have been successful. The latter are, as a rule, made from oxidised oils or from oils that have been treated with sulphur or chlorine. These are useful for certain purposes when mixed with rubber, because they lessen the cost while not interfering with the efficiency of the article.

RECLAIMED RUBBER.—This is now used in great quantities, and affords a perfectly safe method for the production of rubber goods at a moderate cost. Old rubber goods are collected and treated by one of several secret processes, which remove not only the dirt and fabric, but also a portion of the sulphur used for its original vulcanisation. The rubber is ground into a fine powder, then sheeted, and sold in various grades, according to the class of material from which it was made.

RUBBER AS APPLIED TO INSULATION.—In the electrical industry rubber is widely applied as an insulating material. It is used either in the form of a thin plastic mass, which surrounds the wire, and is then vulcanised, or in the form of tape, either for direct insulation or for making joints. In the form of Vulcanite or Ebonite it is of even greater service in the shape of plates, tubes, rods, handles for switches, etc. In submarine cable work vulcanised rubber has been used with success, though for some reason its use in this direction has never become very great. In 1904 a discovery was made by which rubber could be so altered in character as to present and actually have most of the characteristics of gutta-percha. This invention consisted in the intimate mixture of rubber with a wax whose melting point had been artificially heightened. Reports upon this invention show that so far as it has been applied it fulfils its claims in a satisfactory manner.

Rubbers, Condenser (*Textile Manufac.*) The pairs of rubbers which have a transverse as well as a rotary motion, so that they both rub and carry the sliver of fibres from the stripping roller to the condenser, causing the flat sliver to have the form of a soft, unspun thread.

Rubbing Board (*Foundry*). A small board used for smoothing flat faces of sand in large moulds.

Rubblework (*Build.*) Masonry built of irregular-sized or broken stone.

Rubellite (*Min.*) A red or pink variety of TOURMALINE (*q.v.*), used as a gem. *See also* PRECIOUS STONES. This variety comes chiefly from Siberia, Ceylon, and Ava.

Rubens' Brown (*Paint.*) An ochreous brown, somewhat lighter than Vandyke brown. It is now obsolete in this country.

Rubens' Madder (*Paint.*) One of the madder lakes, rich in hue. Now obsolete under this name. *See* LAKES.

Ruberythric Acid (*Chem.*) $C_{14}H_6O_2(OH).O.C_{12}H_{14}O_8(OH)_7$. The glucoside of alizarin (*q.v.*) Yellow needles, soluble in hot water; slightly soluble in alcohol; soluble in alkalis with red colour. Hydrolysed by dilute sulphuric acid to alizarin and glucose. It is obtained from madder root by boiling with absolute alcohol.

Rubicelle (*Min.*) An orange red variety of SPINEL (*q.v.*), used as a gem.

Rubidium (*Chem.*) Rb. Atomic weight, 85. A silvery white metal; melts at 38°; decomposes water like potassium, which it closely resembles. It may be obtained by heating the hydroxide with magnesium. It occurs widely distributed, but in small quantity; it is found in lepidolites, in carnallite, in many mineral springs, in argol, tobacco ash, in beetroot. Its salts are quite similar to those of potassium, but the platinum double chloride is much less soluble in water than that of potassium, and this fact enables them to be separated. Rubidium gives a characteristic flame spectrum, two lines in the violet and two in the red being very characteristic. Rubidium bromide is occasionally used in medicine.

Rubric. (1) A mediæval manuscript or early printed book in which the initial letters were written or printed in red, or in which some portion of the text was written or printed in red to distinguish it. (2) The title of a statute, which was formerly written in red ink. (3) In prayer books, the directions for conducting the service, often printed in red; hence (4) An ecclesiastical injunction or rule.

Rubricated Letters (*Typog.*) Initial or capital letters printed in red ink.

Rubus (*Botany*). An important genus of the order *Rosaceæ*, including the Raspberry (*R. idæus*), Cloudberry (*R. chamæmorus*), Blackberry (*R. fruticosus*), Dewberry (*R. cæsius*).

Ruby (*Typog.*) *See* TYPE.

——, **Almandine** (*Min.*) A violet variety of SPINEL (*q.v.*), used as a gem.

——, **Balas** (*Min.*) A rose red variety of SPINEL (*q.v.*), used largely as a gem under the name RUBY.

Ruby, Oriental (*Min.*) This is the true RUBY; it is a variety of CORUNDUM (*q.v.*) of a characteristic red colour, known as "pigeon's blood." The chief localities for the true Ruby are Burmah, Ceylon, and China. *See also* PRECIOUS STONES.

Ruby Pin *or* **Roller Pin** (*Watches*). The impulse and unlocking pin of a lever escapement, acted upon by the fork of the lever, and fixed in the roller on the balance staff. *See* LEVER ESCAPEMENT.

Ruby Silver (*Min.*) *See* PYRARGYRITE *and* PROUSTITE.

Rudented (*Architect.*) *See* CABLED COLUMN.

Ruhig (*Music*). The German equivalent to Calmato. Quiet, calm.

Ruhmkorff's Coil (*Elect.*) An INDUCTION COIL (*q.v.*)

Rule (*Eng., Carp., etc.*) The measuring instrument used in a great variety of trades. It is usually made of boxwood or of steel, and divided into inches and fractions of an inch. *See* WEIGHTS AND MEASURES.

—— (*Typog.*) Strips or lengths of metal or wood of the same height as type and of different widths. The face or printing surface may be plain or ornamental. Brass rule ranges from 12 to pica up to pica in thickness; zinc or wood rule usually from nonpareil upwards.

Rule Border (*Typog.*) Metal or other border lines to form a frame or line round a page.

Rule Cutter (*Typog.*) A small machine for cutting brass or other rule in required lengths.

Ruling Gradient (*Civil Eng.*) *See* GRADIENT.

Rum. A spirit obtained by distillation from the fermented skimmings of sugar boilers or the drainings of sugar barrels. When first distilled it is colourless, but is afterwards coloured with burnt sugar. The amount of alcohol present is from 50 to 60 per cent.

Rumble (*Eng.*) A revolving cylinder, inside which small castings are sometimes placed, in order that the sand, etc., from the mould may be removed by their rubbing together

Rumford's Photometer (*Light*). *See* PHOTOMETERS.

Run (*Build., etc.*) A term applied to Lineal measurements, which are said to be made by the "foot run," etc.

—— (*Eng., Carp., etc.*) The deviation of a tool, *e.g.* a saw or drill, from its proper direction while in action.

—— (*Mining*). (1) The direction of a vein. (2) The falling in of parts of a working.

—— (*Printing*). The number of impressions taken from a forme.

—— (*Textile Manufac.*) An American counts base for yarns, being a length of 1,600 yards. A 1-run yarn equals 1,600 yards to 1 lb. *See* COUNTS.

Runner (*Foundry*). The channel by which fluid metal runs into a mould. *Cf.* GATE.

Runner Head (*Moulding*). The mass of solidified metal filling the top of a runner (*q.v.*) These pieces of metal are usually broken off while still hot.

Runner Pin *or* **Stick** (*Foundry*). A rod used for forming a runner (*q.v.*) in a mould; it serves as a pattern for the channel, and is withdrawn in the usual way after the sand has been rammed round it.

Runners (*Typog.*) Figures placed down the side of a page to indicate the position and number of a particular line.

Running (*Music*). A defect in an organ which allows a pipe or pipes to speak when only one or two soft stops are drawn out. It is caused either by the upper board (*see* ORGAN, p. 439) not being screwed down tight, or by the wind getting from one channel to another.

Running Centre Chuck (*Eng.*) A DRIVING CHUCK (*q.v.*)

Running Down (*Met., etc.*) Melting a quantity of metal.

Running Gate (*Foundry.*) A RUNNER (*q.v.*), as opposed to a RISER (*q.v.*)

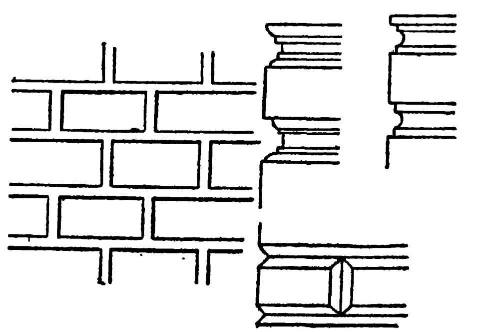
Run On (*Typog.*) *See under* PROOF CORRECTIONS.

Rupert's Drop (*Glass Manufac.*) A small portion of molten glass, in the shape of a tear, which has been dropped into boiling water, thereby becoming case hardened. Should the end of the tear be broken or the surface cut, the entire mass will break up into small fragments. This shows the necessity for annealing glass.

Russia Leather. Originally a speciality of Russia, where it was made from the skins of young cattle, but now made in many other countries besides and from various skins, *e.g.* sheep and goat skins. After being tanned like other light leathers (*see* LEATHER MANUFACTURE), it is treated on the flesh side with an oil distilled from birch bark and buds, which gives it the characteristic smell. Genuine Russia leather is very durable and is extensively used in the more expensive styles of bookbinding.

Rust (*Chem.*) A name given to the product formed by the oxidation of iron under various conditions. If iron is strongly heated in air it forms a mixture of oxides varying in composition between Fe_3O_4 and Fe_2O_3, the latter being the richer in oxygen. When iron is exposed to air at the ordinary temperature it slowly rusts; this also is a process of oxidation, leading ultimately to ferric hydroxide, $Fe(OH)_3$; iron does not rust in quite dry air, but ordinary air contains water vapour and carbonic acid, and these cause iron to rust in air. The action is facilitated by presence of acids and retarded by alkalis. To prevent iron rusting it is galvanised—that is, coated with zinc; or it is treated by Barff's process (*q.v.*)

Rustication (*Architect.*) Any method of emphasising the joints in masonry. This can be done either



RUSTICATION.

by rebating, chamfering, or moulding the stones at the joints, or by several methods of working the face of the stones, such as vermiculating and hammer dressing.

Rusting. The surface of iron is sometimes coated with rust intentionally, *e.g.* iron patterns are rusted and then varnished with shellac.

Rust Joint (*Eng.*) A joint in iron piping made by filling up the gap with a mixture of iron turnings and sal ammoniac (ammonium chloride); this rusts into a hard, watertight mass.

Rustre (*Her.*) A pierced lozenge. The piercing is round and must not be confused with the Mascle, which is a lozenge voided. *See under* HERALDRY.

Ruthenium (*Chem.*) Ru. Atomic weight, 102. A rare metal occurring in small quantity along with platinum. It is white, very difficultly fusible, insoluble in acids, oxidised on heating in air. It forms chlorides, $RuCl_2$ and $RuCl_3$, and oxides, RuO, Ru_2O_3, RuO_2, and RuO_4. RuO_4 is volatile. It also forms ruthenates (red coloured) and perruthenates (green coloured), which resemble the manganates and permanganates in their behaviour.

Rutherford's Maximum and Minimum Thermometer (*Heat*). *See* MAXIMUM AND MINIMUM THERMOMETERS.

Rutile (*Min.*) Oxide of Titanium, TiO_2. Titanium = 61, oxygen = 39 per cent. Tetragonal, often in acicular aggregates, sometimes radiating through Quartz crystals. Colour brown to black. Sometimes in geniculate twins. Some localities are Glen Finnart, Crianlarich, and Killin, in Scotland; Co. Donegal; Limoges; Castile; St. Gothard; Brazil; Brevig, in Norway; Massachusetts, etc.

Rybat (*Build.*) A Scotch term for the stones (inband and outband) that form the reveal, recess, and jamb of an opening.

Rye. *Secale cereale* (order, *Gramineæ*). In composition rye closely resembles wheat, its proteids forming, with the addition of water, a kind of glutin. Rye bread in nutritive value falls little short of wheat, but it is somewhat heavy, very acid, indigestible, and apt to cause diarrhœa.

Rymer (*Eng.*) A REAMER (*q.v.*)

S (*Chem.*) The symbol for SULPHUR (*q.v.*)

Sable (*Her.*) Black. This tincture is represented by vertical and horizontal lines crossing. *See* HERALDRY.

Saccharic Acid (*Chem.*) $COOH(CHOH)_4COOH$. A white deliquescent solid; soluble in water and in alcohol; decomposes at 100°; its solution is dextrorotatory, and the rotation increases on standing. It readily forms a lactone—

$$\underbrace{COOH.CHOH.CH.(CHOH)_2CO}_{O\text{———————}}$$

which crystallises in leaves. The acid does not reduce Fehling's solution, but reduces warm ammoniacal silver nitrate. Hydrochloric acid reduces it in part to adipic acid, $COOH(CH_2)_4COOH$; concentrated nitric acid oxidises it to oxalic and tartaric acids. Its ammonium salt yields pyrrole (*q.v.*) on dry distillation. Saccharic acid is prepared by oxidising glucose or starch with nitric acid of specific gravity 1·15. The acid is isolated by making the acid potassium salt, which is sparingly soluble in water, decomposing this with silver nitrate, and treating the latter with hydrochloric acid.

Saccharimeter. An apparatus for measuring the amount of rotation of the plane of polarisation produced by a solution of sugar or other optically active substance. *See* POLARISATION.

Saccharimetry. The measurement of the amount of sugar in a given volume of solution by means of a SACCHARIMETER. *See* POLARISATION.

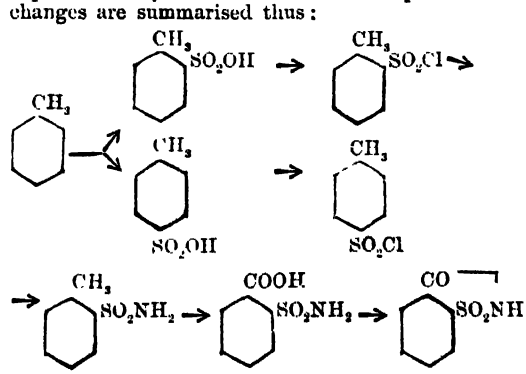
Saccharin (*Chem.*) This name has been given to two totally different compounds: (1) The LACTONE OF SACCHARINIC ACID—

$$\begin{array}{c} \qquad\qquad\qquad\qquad\quad CH_3 \\ CH_2OH.CH.CHOH.\overset{|}{C}.OH. \\ \qquad\quad |\qquad\qquad\qquad | \\ \qquad\quad O\text{————————}CO \end{array}$$

It is a solid which crystallises in shining prisms showing double refraction. It is obtained by adding fresh slaked lime to a boiling dilute solution of dextrose or lævulose. The calcium is removed from the cooled and filtered solution by carbon dioxide and oxalic acid. On concentrating the filtrate from the calcium carbonate and oxalate, saccharin crystallises out after some time. (2) The ANHYDRIDE OF ORTHOSULPHAMIDOBENZOIC ACID—

$$C_6H_4\left\langle\begin{array}{c}CO\\SO_2\end{array}\right\rangle NH$$

It is known by many names, *e.g.* sulphobenzoimide, benzoylsulphonamide, etc. It is usually met with in the form of a white powder, which really consists of very small crystals; melts at 220°; sparingly soluble in cold water, much more soluble in hot water and in alcohol; soluble in acetone, from which it crystallises well. Saccharin has an intensely sweet taste; estimates of its sweetness vary from 240 to 550 times that of cane sugar (according to the purity of the product and delicacy of the sense of taste in the observer); hence it is now much used as a sweetening agent, but, unlike sugar, it is not a food. Like other imides, it behaves as an acid, forming salts with alkalis which are very soluble in water and still retain the sweetness of saccharin itself; also it forms an ethyl derivative with ethyl iodide, which is tasteless, and an acetyl derivative with acetyl chloride. Saccharin is prepared from toluene by acting upon it with concentrated sulphuric acid at a temperature not exceeding 100°. The mixture of ortho- and paratoluene sulphonic acids is made into the sodium salts, and these are acted on by phosphorus trichloride in a stream of chlorine. The phosphorus oxychloride produced is distilled off, and on strongly cooling the remaining liquid much of the paratoluene sulphonic chloride crystallises out. The still liquid portion is treated with dry ammonium carbonate when the amide is formed. The amide is oxidised by potassium permanganate solution, the liquid being always kept neutral by addition of alkali as required. The changes are summarised thus:



Prepared in this way the product is contaminated

with 30 to 40 per cent. of parasulphamidobenzoic acid. To free it from this, advantage is taken of the fact that the para-acid is almost insoluble in hot xylene, while saccharin is easily soluble (patented process). Saccharin is also made by other processes, all protected. Owing to its extensive use as a sweetening agent in place of sugar, there is a heavy duty (twenty shillings per pound) on saccharin.

Saccharose (*Chem.*) A name for CANE SUGAR (*q.v.*)

Sackbut (*Music*). A musical instrument. (1) That mentioned in the Bible was a species of harp. (2) The old English bass trumpet, having a slide like a trombone.

Sacring Bell, Sancte Bell, Sanctus Bell. In the Roman Catholic Church the small bell that is rung at the singing of the *Sanctus* and the Elevation of the Host.

Sacristy (*Architect.*) A room either in or adjacent to a church. It contains the vessels used in various ceremonies, and is used as a robing room by the priest. It is more generally known as the VESTRY.

Saddle (*Eng.*) (1) The support or bed on which a boiler rests. (2) The baseplate of various parts of machines, especially the baseplate of a Slide Rest (*q.v.*)

—— (*Plumb.*) The piece of lead over the rolls (*q.v.*) on a flat.

Saddle Backed (*Build.*) A form of coping stone weathered (sloping) on the top towards both sides of a wall.

Saddle Boiler (*Build.*) A form of boiler used for heating water in a house. The boiler is arched at the base, the arch serving as a conduit for the products of combustion between the grate and the chimney.

Saddle Cramp (*Carp. and Join.*) A wooden cramp for wedging-up stairs.

Saddle Flange (*Eng.*) A support curved so as to fit a cylindrical object which rests upon it, *e.g.* a large pipe.

Saddle Key (*Eng.*) A KEY (*q.v.*) whose lower surface is curved so as to rest on a shaft, instead of being let into a recess or key way or lying on a flat filed on the shaft.

Saddle Tank (*Eng.*) A water tank fitting over the boiler of a locomotive, like a pack saddle.

Safe (*Plumb.*) A lead tray laid under baths, closets, etc., to catch water that splashes over.

Safe Edge (*Eng.*) An edge of a file which is left unprovided with teeth; it can be used in an angle or corner in order to act on one surface only.

Safe Load (*Eng., etc.*) The amount of load or force to which a structure or member of a structure can be subjected without risk. It should be so chosen that the strains produced always lie well within the ELASTIC LIMIT (*q.v.*) of the material.

Safety, Factor of (*Eng., etc.*) *See* FACTOR OF SAFETY.

Safety Fuse, Cut Out, etc. (*Elect. Eng.*) A device by which a circuit is broken when the current in it rises above a certain value. A FUSE is the simplest form; it consists of a short wire or strip of tin or some fusible alloy, which melts if the current rises to a certain value.

Safety Ladle (*Met., Foundry, etc.*) A large foundry ladle, provided with gearing by which it can be tilted gradually without the risk of overurning.

Safety Lamp (*Mining*). A lamp designed to give light in gaseous workings without the danger of igniting inflammable mixtures of firedamp and air. The construction of the ordinary safety lamp is based upon the principle that although air can enter through the meshes of a wire gauze surrounding the flame, no flame can pass from the inside to the outside of the gauze, because the metallic wires conduct away the heat so quickly that the temperature of the gases outside cannot rise to the point of ignition. There are many types of safety lamps, but although they differ from each other in such details of construction as size, shape of glass and gauze, method of lighting and locking, arrangements for testing for gas, the wire gauze is retained in every type, no better means of preventing the communication of flame from the inside to the outside of the lamp having been discovered. A few electric lamps are in use, but these are unsuitable for fiery mines, as it is necessary for a lamp not only to be safe in inflammable mixtures, but to give *immediate indication* of the presence of gas in the workings. *See* METHANE.

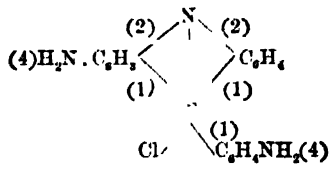
Safety Lift (*Eng., etc.*) A lift or hoist provided with some means of preventing a sudden descent.

Safety Plug (*Eng.*) A plug of fusible metal used in boilers, etc. It melts and allows the escape of steam if the temperature (and therefore the pressure) rise above a certain point.

Safety Valve (*Eng.*) A valve in a boiler which opens and allows the escape of steam when the pressure exceeds a certain value. The valve is kept closed either by springs or by properly adjusted weights. The weights may act directly (as in the Cowburn valve) or may be attached to a lever, in which case the force exerted on the valve is adjustable within certain limits. *See* STEAM ENGINE.

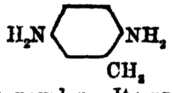
Safflower (*Botany*). The compressed flowers of *Carthamus tinctorius* (order, *Compositæ*)—a plant cultivated in the south of Europe, Egypt, etc—are used as a yellow and red dye for silk. When powdered they are the source of one kind of rouge (*q.v.*)

Saffranines (*Chem.*) A class of dyes the simplest member of which is *Phenosaffranine* (diamidophenylphenazonium chloride)—



which forms green leaflets or steel blue needles, according as it is crystallised from dilute hydrochloric acid or water. Its solution is red, and the alcoholic solution shows yellow-red fluorescence; with a large excess of hydrochloric acid it is blue (diacid salt); with concentrated sulphuric acid the solution is green (triacid salt). It dyes cotton, mordanted with tannin and tartar emetic, red; on silk it gives a rose colour. On reduction with stannous chloride it yields the leuco-compound; on exactly precipitating the sulphate with baryta water it yields the colour base which has the same colour as its monacid salts (red). Phenosaffranine is obtained by oxidation in neutral solution with potassium dichromate, of (1) a mixture of paraphenylenediamine and aniline in the proportion of

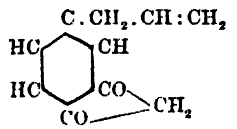
one molecule of the former to two of the latter; (2) a mixture of dipara-amidodiphenylamine and aniline in molecular proportions. An indamine (*q.v.*) is an intermediate product. Ordinary saffranine is a mixture of phenotolusaffranine and tolusaffranine, and is obtained by oxidation of a mixture of aniline, orthotoluidine, and paratoluylenediamine—



It is a red-brown powder. Its properties are very similar to those of phenosaffranine. A 0·1 per cent. solution in presence of caustic potash forms a delicate and reliable test for sugar (dextrose) in urine; the dextrose turns it yellow on warming.

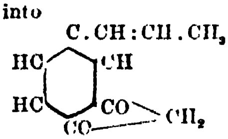
Saffron (*Botany*). The dried stigmas of the flowers of *Crocus sativus* (order, *Iridaceæ*) yield the SAFFRON of commerce. It was once used as an orange dye, but is now chiefly employed as a flavouring agent.

Safrols. (1) SAFROL,



(Allylpyrocatechol methylene ether). A colourless liquid; melts at 8°; boils at 232°; the smell of essential oil of sassafras is due to safrol, which forms about 90 per cent. of this oil. It is largely used in perfuming cheap soaps. It occurs in oil of sassafras, oil of camphor, and in the oil from *Ilicium religiosum*. From the first of these oils it is easily obtained by fractional distillation and freezing of the fractions; oil of camphor also furnishes large amounts of safrol. When heated with alcoholic potash it is converted into

(2) ISOSAFROL,



(Propenylpyrocatecholmethylene ether). A colourless liquid; boils at 249°; smells like safrol, but weaker. It is made from safrol, as mentioned above. On oxidation with potassium dichromate and sulphuric acid, it gives piperonal and acetaldehyde. *See* PIPERONAL.

Sag (*Eng., etc.*) A bending downward, produced in a member of a structure either by its own weight or by the load which it carries. *See* DEFLECTION.

Sagger (*Met.*) A cast iron box or crucible in which castings are packed for annealing in the preparation of malleable castings.

—— (*Pot.*) *See* SEGGAR.

Sago (*Botany*). The starchy matter obtained from the pith of the SAGO PALM (*Metroxylon sagu*; order, *Palmæ*), a native of the East Indies. It is prepared by crushing and repeated washings.

Sagum (*Archæol.*) The cloak of the Roman soldier, consisting of an oblong piece of coarse cloth fastened on the left shoulder. *Cf.* CHLAMYS *and* TOGA.

Saint Bees' Sandstones. *See* BUILDING STONES.

Saint Elmo's Fire (*Meteorol.*) An electrical discharge resembling the brush discharge of electrical machines, seen at the tops of trees, spires, masts, and other pointed objects during thunderstorms.

Salade (*Arm.*) An open form of helmet or headpiece, sometimes provided with a movable visor; worn in the fifteenth century and after. It succeeded the bascinet (*q.v.*) *See also* ARMOUR *and* MORION.

Sal Alembroth (*Chem.*) *See* MERCURY COMPOUNDS.

Salamander (*Met.*) The mass of hard slag which remains on the hearth of a furnace when the fires are drawn.

Sal Ammoniac (*Chem.*) Ammonium chloride. *See* AMMONIUM COMPOUNDS.

—— (*Min.*) Ammonium chloride, NH_4Cl; cubic; occurring in minute octahedrons or as an efflorescence. White or yellowish. Very soluble in water. It is found rarely in relation to some coal and shale beds, as at Hurlet, near Paisley; more often in volcanic regions, as at Vesuvius, Etna, and Stromboli.

Salcional, Salicet, *or* **Salicional** (*Music*). An organ stop of soft tone and reedy quality, and having a very small scale. It is very similar to the dulciana.

Salicaceæ (*Botany*). A dicotyledon order, including the Willows and Poplars.

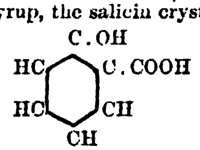
Salicin (*Chem.*) $C_6H_4\begin{cases} OC_6H_{11}O_5 \\ CH_2OH \end{cases}$

A glucoside. It forms small shining trimetric crystals; melts at 188°; soluble in water (1 in 23) and in alcohol; bitter taste; lævorotatory. Used in medicine as a stomachic and in rheumatism. On gentle oxidation by nitric acid it yields the aldehyde helicin—

$$C_6H_4\begin{cases} OC_6H_{11}O_5 \\ CHO \end{cases}$$

Hydrolysed by ptyalin, emulsin, and dilute acids to glucose and saligenin, the latter resinising when acids are used. It occurs in the bark of many varieties of willow and poplar. It is obtained from willow bark by boiling with water, filtering, and concentrating the filtrate, which is then digested for twenty-four hours with oxide of lead; on filtering and evaporating to a syrup, the salicin crystallises out.

Salicylic Acid,



(Orthohydroxybenzoic acid). White small needles usually, or long needles or prisms; melts at 156°; slightly soluble in water (1 part in 444 at 15°); much more soluble in hot water; soluble in alcohol, ether, and chloroform; taste sweet first, acid to burning afterwards. Powerful antiseptic, and therefore largely used as a food preservative, especially in jams, which practically always contain it (1 in 3,500 and more); also used in medicine, both as an ointment and as a specific in rheumatic fever. (The sodium salt, which is much more soluble in water than the acid, is much used.) The artificial acid is liable to contain parahydroxybenzoic acid and the methyl homologues of salicylic acid, of which orthocresotic acid, $C_6H_3.CH_3.OH.COOH.(1:2:3)$, is certainly poisonous; but by using pure phenol and properly regulating the temperature the artificial acid can be obtained pure. Salicylic acid distils in steam; ferric chloride gives a violet colour to its solution. When heated alone it gives some salol (*q.v.*) and xanthone (*q.v.*); heated with soda lime, it gives phenol. On reduction with sodium

and amyl alcohol it gives normal pimelic acid, $COOH.(CH_2)_5COOH$. With caustic potash or soda it forms two series of salts, *e.g.*

$$C_6H_4\begin{cases}OH\\COOK\end{cases} \text{ and } C_6H_4\begin{cases}OK\\COOK\end{cases}$$

the latter, formed by using excess of the alkali, being decomposed by carbonic acid into the former. Salicylic acid occurs in the form of its methyl ester in oil of wintergreen and oil of sweet birch (*Betula lenta*); both oils contain about 99 per cent. of the ester. It is prepared from these by hydrolysis with caustic soda—

$$C_6H_4\begin{cases}OH\\COOCH_3\end{cases} + NaOH = C_6H_4\begin{cases}OH\\COONa\end{cases} + CH_3OH.$$

The methyl alcohol is distilled over; the residual liquid is diluted, filtered, and acidified with hydrochloric acid, when the salicylic acid crystallises out. It is purified by recrystallisation. The artificial acid is prepared from sodium phenate; phenol is dissolved in caustic soda, and the solution evaporated to dryness with constant stirring:

$$C_6H_5OH + NaOH = \underset{\text{Sodium Phenate.}}{C_6H_5ONa} + H_2O.$$

The dry sodium phenate is heated in a stream of carbon dioxide at 180 to 200°, when phenol sublimes and disodium salicylate remains:

$$2C_6H_5ONa + CO_2 = C_6H_4\begin{cases}ONa\\COONa\end{cases} + C_6H_5OH.$$

The acid is liberated from its disodium salt by hydrochloric acid. If potassium phenate is used instead of sodium phenate, a mixture of the dipotassium salts of orthohydroxy- and parahydroxybenzoic acids is obtained at 150°; at 220° only dipotassium parahydroxybenzoate is formed. Another method is to heat the sodium phenate at 120° to 130° with carbon dioxide under pressure, when the sodium phenyl carbonate first formed is converted by a molecular rearrangement into sodium salicylate:

$$C_6H_5ONa + CO_2 = CO\begin{cases}ONa\\OC_6H_5\end{cases}$$

$$CO\begin{cases}ONa\\OC_6H_5\end{cases} = C_6H_4\begin{cases}OH\\COONa\end{cases}$$

from which the acid is obtained as above. Salicylic acid can be obtained in many other ways, *e.g.* from anthranilic acid (*q.v.*) by the diazo-reaction (*q.v.*); by a modification of Reimer's reaction (*q.v.*)

Salicylic Acid in Foods (*Foods*). Salicylic acid is frequently added to milk and other articles of food as a preservative. According to a report of a Departmental Committee of the Local Government Board in 1901, salicylic acid should not be used in larger proportion than one grain in a pint or pound of food.

Salicylic Aldehyde (*Chem.*) $C_6H_4\begin{cases}OH\\CHO\end{cases}$ (1:2).

A pleasant smelling, colourless liquid; boils at 196°; soluble in water; ferric chloride colours its solution violet; distils in steam. It is used in perfumery, and as a flavouring agent for liqueurs. It is easily oxidised to salicylic acid, and reduced to saligenin. Does not reduce Fehling's solution. It occurs in oil of meadowsweet. Salicylic aldehyde is obtained by distilling a mixture of salicin, potassium dichromate, and very dilute sulphuric acid, and extracting the distillate with ether. It is also obtained by Reimer's reaction (*q.v.*)

Salient (*Her.*) A beast in the act of springing. *See* LION SALIENT.

Salient Angle. An external angle, one in which the apex points outward.

Salient Pole (*Elect. Eng.*) When the poles of a dynamo project inward towards the armature, from a closed ring of iron, and are each magnetised by one coil only, they are termed SALIENT POLES, as distinguished from CONSEQUENT POLES (*q.v.*) *See* DYNAMO, Fig. 1.

Saligenin (*Chem.*) $C_6H_4\begin{cases}OH\\CH_2OH\end{cases}$ (1:2).

The alcohol corresponding to salicylic acid. It is a white crystalline solid; melts at 82°; soluble in water, alcohol, ether. It is formed by the hydrolysis of salicin (*q.v.*); also by condensing phenol with either methylene chloride, CH_2Cl_2, or formaldehyde with caustic soda. Ferric chloride gives a blue colour with saligenin.

Salinometer (*Eng.*) An instrument for ascertaining the amount of dissolved salt in the water used in ships' boilers, etc. The salt increases the density and raises the boiling point of the water. If either of these quantities be determined, the amount of salt can be found from tables; or the amounts corresponding to given densities or given boiling points may be marked on the instrument.

Saliva (*Zool.*) The fluid secreted by the salivary glands. It consists of water containing mucin, ptyalin (a ferment acting on starch), and small quantities of various salts. It is the first of the various fluids which act upon food in the processes of digestion.

Salle (*Paper Manufac.*) A room devoted to sorting and packing sheets of paper.

Salol (*Chem.*) $C_6H_4\begin{cases}OH\\COOC_6H_5\end{cases}$ (Phenyl salicylate).

A white crystalline solid with faint aromatic smell; melts at 43°; boils at 172° under 12 mm. pressure of mercury; insoluble in water; soluble in alcohol; very soluble in ether and chloroform. It is used in medicine as an antiseptic and in rheumatism. Prepared by heating salicylic acid alone at 220°, or by the action of phosphorus oxychloride on a mixture of salicylic acid and phenol. Heated alone, it gives xanthone. Saponified by boiling caustic soda.

Salon (*Art*). One of the two annual exhibitions of works by living artists in Paris. One is held at the Palais of the Champs Elysées, the other at the Salon of the Champs de Mars.

Salopian (*Geol.*) The middle division of the SILURIAN ROCKS. It comprises all the strata from the top of the Lower Ludlow to that of the Tarannon Shales. In the Lake District and in Southern Scotland the rocks of Salopian age attain to a thickness of many thousand feet. The rocks above the Salopians are now classed as DOWNTONIAN and the remainder of the Silurian Rocks below as VALENTIAN. This classification is based upon the evidence afforded by the included organic remains.

Sal Prunella (*Chem.*) Potassium nitrate (*see* POTASSIUM COMPOUNDS) which has been melted and cast into balls or sticks.

Salt (*Geol.*) Salt, in the form of rock salt, occurs under a considerable variety of geological conditions; but the deposits best known on account of their economic importance occur in connection with stratified rocks, which appear, in most cases, to have been formed under arid, or even desert, conditions. In some few cases deposits of rock salt may be due to (1) the desiccation of bodies of sea water which have dried up after having been cut off from the open sea; or (2) to the drying up of large shallow sheets of sea water which have evaporated under such geographical conditions as now occur in the Runn of Cutch. But the majority appear to have originated in inland lakes. The genesis of the salt in such a case as this last may be somewhat as follows: During storms large quantities of sea spray are driven far inland by the winds, and their dissolved salts are eventually left, for a time, in the atmosphere in the form of dust. Upon these solid particles condensation of some of the aqueous vapour present in the atmosphere occurs, so that the sea salt (amongst other substances) forms the nuclei of drops of rain, flakes of snow, particles of fog, etc. Descending to the Earth, this mixture of sea salts and water flows down hill and seaward, and is usually returned to the ocean, to await the commencement of another cycle of change. But in the areas of inland drainage, such as the Dead Sea, the Salt Lake, the Caspian, and the inland lakes of Central Asia, the water is dissipated by evaporation, and returns to the clouds, leaving the dissolved constituents behind. In time these may accumulate into thick beds, which may eventually be covered by desert sands, and so be preserved for a time from waste. Salt deposits found in this way (or in others) occur on various geological horizons. In Britain they are confined to the Bunter Marls, as at Middlesboro', or to the Keuper Marls, as in Cheshire, both horizons belonging to the Upper New Red or Trias. *See* SODIUM CHLORIDE *under* SODIUM COMPOUNDS.

—— (*Min.*) *See* ROCK SALT.

——, **Formation of** (*Geol.*) The primary source of rock salt may be any one of five. (1) The salt may be simply washed out of some older rocks in which it occurred, and be subsequently re-deposited. (2) It may arise through the chemical combination of chlorine, through the medium of hydrochloric acid, with other sodium compounds. (3) It may be concentrated from the efflorescences given off by many active volcanoes, which boil off the H_2O from sea water, and use up most of the residues in making eruptive rocks. (4) It may be due to the evaporation of shallow basins of sea water in areas permanently, or periodically, cut off from the open sea; or (5) it may be of cyclic origin, as follows: The aqueous vapour present in the atmosphere undergoes condensation only upon (*a*) some few vapours, (*b*) solid particles of one kind or another. Amongst those which are most potent in this connection, particles of salt rank foremost. This salt dust, which is widely present in the lower strata of the atmosphere, is due to the action of the wind upon sea water, which it lashes into spray and drives far inland. Upon these salt dust particles much of the rain and snow that reach the Earth has been condensed. Flowing downhill and seawards, the water, with its minute charge of salt, finds its way into rivers, and thence, in usual course, back to the sea, where the cycle is re-commenced. But in the case of the areas of inland drainage, which occupy some 11,486,250 square miles, or nearly one-fifth of the total surface of the land, *the water does not return to the sea*, but is dissipated by evaporation, so that, however minute the quantity of dissolved matter it contained, in time the amount begins to tell, and in course of ages thick deposits are formed. It is mainly from such deposits that our chief supplies are drawn.

Saltando (*Music*). Jumping.

Salt Cake Process. *See* ALKALI.

Salting (*Eng.*) The deposition of salt in the boilers of ships. It is not injurious so long as the amount is small.

Saltire (*Her.*) Formed by a bend and bend sinister crossing each other. St. Andrew's Cross is a saltire. *See* HERALDRY.

Salt Lakes (*Geol.*) The majority of recent salt lakes occur within areas in which the rainfall of the hydrographical basin in which they occur is exactly balanced by evaporation. The Dead Sea, the Salt Lake, and the lakes of Central Asia are cases in point. In all of these the saltness is due to the continued accumulation of saline matters, derived in the first instance from sea spray, which has been carried down in rain water, and which, instead of being returned to the sea, as is usually the case under other geographical conditions, is left behind when the water evaporates.

Salt of Sorrel (*Chem.*) Same as Salts of Lemon (*q.v.*) *See also under* OXALIC ACID.

Saltpetre (*Chem.*) A common name for potassium nitrate. *See* POTASSIUM COMPOUNDS.

—— (*Min.*) *See* NITRE.

Salts (*Chem.*) Compounds derived from acids by the replacement of the whole or a part of the acid hydrogen by metals, or by groups of elements which act as metals. Examples:

Hydrochloric acid, HCl.	Sodium chloride, $NaCl$.
	Ammonium chloride, $NH_4.Cl$.
Sulphuric acid, H_2SO_4.	Sodium Sulphate, Na_2SO_4
	Sodium hydrogen sulphate, $NaHSO_4$.
Acetic acid, CH_3COOH.	Lead acetate $(CH_3COO)_2Pb$.
	Ethyl acetate, $CH_3COOC_2H_5$.

Salts derived from hydrochloric acid and the other halogen acids are called haloid salts. *See* HALOID SALTS. Salts like ethyl acetate, derived from an organic acid and an alcohol, or from an alcohol and an inorganic acid, are called ethereal salts or esters. *See* ESTERS. When the whole of the acid hydrogen is replaced by metal, the salt is called a NORMAL SALT. When the whole of the acid hydrogen is not replaced by metal, the salt is called an ACID SALT. An acid salt may be regarded also as a compound formed by the union of a normal salt with the corresponding acid; in some cases this appears to be the only way of regarding them, *e.g.* potassium quadroxalate, $KHC_2O_4 . H_2C_2O_4 2H_2O$. Calcium acid carbonate, $CaCO_3H_2CO_3$. When an acid is added to an excess of a base there are often formed in the case of weak bases BASIC SALTS; these may be regarded as compounds of the normal salt with the basic oxide, or as compounds derived from the basic hydroxide by replacement of part of the hydroxyl hydrogen by the acid radical: *e.g.*

$$\text{Basic bismuth chloride, } Bi_4O_3Cl_6 = Bi_2O_3 . BiCl_3.$$

$$\text{Basic lead acetate, } PbO . Pb(C_2H_3O_2)_2 . H_2O,$$

may also be regarded as $Pb \begin{cases} OH \\ OOC.CH_3 \end{cases}$

Very frequently two salts combine together to form

a complex salt, which is called a DOUBLE SALT. For example, if solutions of ferrous sulphate and ammonium sulphate are mixed together in molecular proportions, the compound ferrous ammonium sulphate, $(NH_4)_2SO_4 . FeSO_4 . 6H_2O$, crystallises out on concentrating the solution. This salt shows all the reactions of an ammonium salt, a ferrous salt, and a sulphate. But there is another kind of double salt formed in a similar way which does not show all the reactions of all the metals and acid which compose it; thus when sodium chloride solution is mixed with platinic chloride solution, a double salt is formed which does not show the ordinary reactions of platinum and a chloride, and on electrolysis only the sodium travels to the kathode. Double salts of this kind are now usually regarded as derived from complex acids. The salt just mentioned is regarded as derived from chloroplatinic acid, H_2PtCl_6, by replacement of the hydrogen by sodium. The term NEUTRAL SALT was formerly much used, and is still met with sometimes, as synonymous with normal salt; but it is best not used or only used when speaking of a salt which has a neutral action towards litmus. With regard to the action of salts on litmus, it is useful to bear in mind that salts of weak bases with strong acids turn blue litmus red, *e.g.* ferric chloride, lead nitrate; salts of strong bases with weak acids turn red litmus blue, *e.g.* sodium carbonate, sodium borate; salts of strong bases and strong acids are neutral to litmus, *e.g.* sodium chloride, potassium nitrate. *See* SOLUTIONS.

Salts in Food (*Foods*). Chloride of sodium (common salt), phosphates of lime, soda, potash, and magnesium are essential for the repair and growth of the body. Lime is required for bone formation, potash for nutrition of formed tissues. Iron is necessary for the formation of the red blood corpuscles. The absence of ordinary salt from food leads to disease and sometimes death.

Salts of Lemon (*Chem.*) Potassium acid oxalate or potassium quadroxalate—

$$KHC_2O_4 \text{ or } KHC_2O_4 . H_2C_2O_4 2H_2O.$$

It is used for removing ink stains and iron stains from linen. Poisonous.

Salt Water. In engineering phraseology this usually means SEA WATER (*q.v.*)

Sal Volatile (*Chem.*) A common name for ammonium carbonate. *See* AMMONIUM COMPOUNDS.

Samara (*Botany*). A dry, usually one-seeded fruit furnished with a projecting wing. The wing may be terminal, as in the White Ash, or it may surround the fruit, as in the Birch. Also called KEY FRUIT.

Samarium (*Chem.*), Sm. Atomic weight, 149. A rare element occurring in samarskite and thorite. It is characterised by its spark spectrum and by the absorption spectra of its salt solutions. Oxide, Sm_2O_3; very faint yellow powder; chloride, $SmCl_3 6H_2O$; topaz coloured deliquescent crystals.

Samian Ware (*Pottery*). The name given to an ancient kind of pottery, either black or red in colour, highly glazed, and with ornament in relief. It has a wide distribution.

Samovar. An urn, usually of copper, used in Russia for boiling water for making tea. It is generally heated by a charcoal fire.

Sample. A small portion of material from which the quality is to be judged.

Sampling (*Assaying, Met., etc.*) The selection of a portion of ore for analysis or assaying, such that its composition accurately represents the average composition of the whole quantity under consideration.

Sancte Bell, Sanctus Bell. *See* SACRING BELL.

Sand (*Geol.*) The term sand is applied indifferently to any finely comminuted mineral matter which has been formed by natural agencies, with the exception perhaps of the dust ejected from volcanoes. Thus there is shell sand, formed of broken shells; coral sand, of broken corals; volcanic sand, arising from broken-down volcanic rocks; and so on. But sand is usually understood to mean fine grained fragmentary mineral matter chiefly composed of quartz grains. In all cases sand of this description is of terrigenous origin, *i.e.* it has been derived in the first instance from the rocks of the land. The primary source of quartz sand is either the quartz of granites or the broken-down material of vein quartz. In no case do flints constitute the parent rock of sand of any kind. Quartz is liberated from granite usually by the chemical decomposition of the rock, started in the first instance by solutions of the humus acids, which in their turn are due to the action of bacteria upon dead organic matter. Quartz so liberated becomes reduced in size by various mechanical agencies, and is sorted out either by running water or by the action of the wind, so that grains of fairly uniform size become associated together. When sand grains are undergoing reduction by the action of running water, the reduction in the size of the grains proceeds at a slower rate with the smaller grains than with the larger, while the rounding by attrition does not, in this case, go on when the sand grains have reached dimensions such that the surface tension between the grain of sand and the water in contact with it balances the gravitational force. When a grain of sand is being worn down, its surface area does not lessen as fast as its weight does, but becomes proportionally larger, so that with each halving of the diameter of, say, a sphere, the ratio of its surface area to its weight is doubled. Thus after a certain stage of reduction is past, sand grains are buoyed up by moving water, and little or no further attrition of the sand grain is possible. Hence sea sand and river sand consist of quartz grains which are either angular or subangular, and are rarely or never round, unless they have been derived from a rock which has been formed under the conditions referred to below. But a very large proportion of the sand on the face of the globe has been formed subaërially. In desert regions, where a very high diurnal range of temperature occurs in consequence of the absence of moisture in the air, such rocks as granite break up under the heavy strain occasioned by these rapid changes of temperature. The quartz, among other substances, is set free by this disintegration, becomes further reduced in size as time goes on, and then begins to undergo transport solely by the action of the wind. This agent bowls the grains of sand against each other through very long periods of time, with the result that the sand grains finally assume a spherical, or, at least, spheroidal shape. So in desert sands, recent or fossil, a large proportion of the sand grains are rounded, instead of being angular, as sand grains of the same size would be if they had been shaped by running water.

Sandal (*Cost.*) A shoe consisting generally of a sole only, attached to the foot by thongs, cords, or loops. In some cases the sandal is supplied with

a heel piece and a cap for the toes. Sandals were worn by most of the ancient nations, and are still worn by some Oriental races. Ancient Egyptian sandals were sometimes manufactured from papyrus.

Sandal Wood, Red. The reddish brown heart wood of the stem of *Pterocarpus santalinus* (order, *Leguminosæ*) is used in medicine as a colouring agent, and also as a dye.

——, True. The true sandal wood of India is the wood of *Santalum album* (order, *Santalaceæ*), a small evergreen tree growing in South India and the Indian Archipelago. It is used in perfumery and in Indian medicine.

Sandarach. A resin used in varnish making; obtained from the tree *Callitris quadrivalvis*, which is found in the north of Africa and shipped from Mogador. Another variety has in recent years been brought to England from Australasia. Sandarach is hard and brittle, and occurs in tears which are of a yellowish white colour. It is sometimes erroneously called "gum juniper."

Sand Bag (*Foundry*). A bag made of some fabric of open texture filled with sand. By shaking the bag fine sand can be dusted over any surface in a mould to form a Sand Joint (*q.v.*)

—— (*Engrav.*) A leather covered cushion filled with sand, used by engravers to fix a plate at an angle convenient for working.

Sand Bank (*Foundry*). A sloping bed of sand on which iron pipes are often cast. The sloping position of the moulds facilitates the escape of the scum

Sand Blast (*Eng., etc.*) A jet of water and steam carrying fine sharp sand in suspension; used for sharpening files, abrading or "grinding" the surface of glass, and various other purposes. *See* GLASS MANUFACTURE.

Sand Box (*Eng.*) A box fitted to a locomotive, tram-car, etc., from which sand can be dropped on the rails in front of the driving wheels, to promote adhesion when the rails are slippery.

—— (*Foundry*). A MOULDING BOX *or* FLASK (*q.v.*)

Sand Burned (*Foundry*). A casting is said to be sand burned when a layer of partly fused silica adheres to the surface, owing to the metal having been poured at too high a temperature. The use of BLACKING (*q.v.*) prevents this fault.

Sand Dunes (*Geol.*) During storms, when the wind comes landward from the sea, considerable quantities of sand are caught up in the waves which beat on the shore. When the waves are driven upon the land, the sand grains carried by them are usually left behind, while the sea water oozes back alone to the sea. Large quantities of sea sand are thus left above high water mark, and these, sorted and re-arranged by the wind, make up sand dunes.

Sanderswood. *See* DYES AND DYEING *and* WOODS.

Sand Grain. *See* ENGRAVING AND ETCHING.

Sand Joint (*Foundry*). The parting surface between the separate parts of a mould.

Sandmeyer Reaction (*Chem.*) The reaction of diazobenzene salts with cuprous salts, described under DIAZO REACTIONS (*q.v.*)

Sandpaper (*Joinery, etc.*) Tough paper covered with finely crushed abrading material. Originally fine sand was used; hence the name. Crushed glass is now employed, and the name GLASS PAPER is therefore more correct.

Sand Pump (*Civil Eng.*) A centrifugal pump by which a mixture of sand and water is raised in dredging a sandy bottom. The pump discharges into a barge in which the sand settles, and the water is allowed to flow away.

Sand Sifter (*Foundry*). A machine used for sifting sand for foundry use.

Sandstones (*Geol.*) Rocks comprised of sand grains cemented by any one or more of various materials, such as limonite, calcite, bituminous matter, and variously coloured in accordance with (1) the nature of the sand grain, (2) that of the cement, (3) the tint subsequently imparted to the rock by infiltration, weathering, etc.

Sand Trap (*Paper Manufac.*) A long narrow box fitted with partitions, used for keeping back knots and mechanical impurities in pulp.

Sand Valve (*Eng.*) A valve used for discharging sand on to the rails in front of the wheels of a locomotive. Cf. SAND BOX.

Sandvent (*Foundry*). Holes of small diameter pierced through the sand of a mould by a rod or wire, in order to allow of the escape of the gases produced when hot metal enters the mould.

Sanger Shepherd Process (*Photo.*) *See* PHOTOGRAPHY IN COLOURS.

Sanguine. Of a blood red colour. In heraldry it is synonymous with the older term MURREY.

Sanidine (*Min.*) A glassy variety of ORTHOCLASE FELSPAR (*q.v.*)

Sanitary Wallpaper (*Dec.*) A variety of paper hangings printed from engraved copper rollers in oil colours. Ordinary paper hangings are printed in distemper colours. *See* PAPER HANGINGS.

Sanitation. Sanitation may be defined as the science of sanitary conditions, and thus comes practically within the province of the sanitary engineer. It is included in the term Hygiene, which also comprehends subjects generally dealt with by the medical man and the analyst. The subjects which come under the above definition of sanitation are numerous, but they appertain chiefly to the supply of pure air and water; the means adopted for the removal and disposal of fœtid and waste products; and the purity of food supply.

AIR.—The air we breathe is a mechanical mixture, and is composed of oxygen, about 21 per cent. by volume; nitrogen, about 79 per cent.; carbonic acid, (CO_2), about ·04 per cent.; watery vapour; small traces of ammonia. Ozone—an allotropic modification of oxygen—is also present sometimes, more especially on the sea coast. As a rule the greater the quantity of ozone present the greater is the purity of the air. The amount of CO_2 present is generally taken as a gauge for the amount of impurity, as if present in quantity it is generally associated with other and more harmful impurities. The amount of CO_2 varies from ·033 in the open country to ·054 per cent in the centre of cities. In badly ventilated rooms this percentage may rise to ·1 or even ·2. Air is polluted in many ways, but chiefly by the respiration of men and animals, by combustion, by emanations from decomposing matter of all kinds, and by countless particles of dust which have a complicated composition.

Bacteria of various kinds are also present, and these are more abundant in towns than in the country, while at a distance of 120 miles from land it is said that none exist. In inhabited rooms the ordinary impurities are derived from respiration and combustion. In respiration each adult gives off about ·65 of a cubic foot of CO_2 per hour, as well as watery vapours and organic impurities. In the combustion of coal and coal gas CO_2 is given off as well as sulphuric acid, sulphide of ammonia, water, and particles of unburnt carbon. An ordinary gas burner which burns 4 cubic feet per hour uses up the oxygen in 32 cubic feet of air, and produces about 8 cubic feet of CO_2.

VENTILATION OF ROOMS.—In order to get rid of these products, which act deleteriously on human beings, ventilation is necessary. In an ordinary dwelling house there are as a rule only two means of ventilation: the fireplace and chimney, which act as an outlet, and the windows, which may act as both inlet and outlet. A chimney acts better when there is a fire in the fireplace. The window is the best ventilator if used as it ought to be, and no ventilation can compare with what is called "perflation," or ventilation by means of the wind blowing through the room. If perflation is combined with sunshine, then a room can not only be ventilated thoroughly but also purified. In large buildings other means of ventilation are necessary, and may be either natural or mechanical. The former depends on the force of the wind and the differences of temperature for its action, while in the latter some form of mechanism such as a fan is employed. In both cases inlets and outlets must be provided. The following are a few of the appliances in use for ventilating purposes: TOBIN'S TUBES are upright inlet tubes fixed inside the room and rising at least 6 ft. above floor level. They generally have valves, and are occasionally fitted with hot water coils inside to warm the air as it passes in. SHERRINGHAM'S VALVE is a small inlet ventilator, with hinged flap, balanced so that the flap falls inwards, the current of fresh air being directed upwards. MCKINNELL'S VENTILATOR is both outlet and inlet, being composed of two tubes one inside the other, the outer acting as inlet and the inner as outlet. One of the most common outlet ventilators used is Boyle's mica flap valve, placed in an opening into the chimney of the room. Ventilating cowls are frequently used on churches, etc. These are generally either Boyle's, Banner's, or Buchan's, and act as outlets. With these proper inlets must also be provided. Ventilating grates and stoves are sometimes used, the most satisfactory of these being Douglas Galton's grate. ARTIFICIAL VENTILATION by fan is now frequently employed in churches, schools, hotels, theatres, etc., and, if the currents are properly directed, is the most satisfactory for large buildings. The air can be cooled, warmed, and purified as required.

WARMING.—In England the open fire is the principal method adopted in houses, and although the most expensive, is not only a ventilator of great value, but gives an air of comfort to a room. In recent years great improvement has taken place in the construction of open firegrates, and some of them, such as Teale's slow combustion grate, are extremely satisfactory and economical. Gas fires are now in common use, but although cleanly and convenient they are not to be recommended for use in bedrooms. STOVES of various patterns are also used, but there is always a chance of the air introduced being burnt if the stove is a ventilating one, and also of the production of carbon monoxide (CO), a very poisonous gas, if the stove is constructed of cast iron. The warming of large rooms, churches, etc., is usually carried out by means of hot water or steam pipes. The system most commonly employed consists of 4-in. iron pipes connected with a boiler heated by a furnace, in which the temperature of the water rarely reaches 212° F. In high pressure systems the water is above this temperature, and the pipes are of wrought iron and of smaller diameter.

WATER AND WATER SUPPLY.—All water for domestic purposes is derived originally from the rainfall, but before reaching the consumer it undergoes numerous changes which materially alter its purity. As a source of direct supply rain water is only occasionally used, and generally only where no other source is available. If collected in the country it is the purest of all waters, but is not pleasant to taste. Upland surface water is rain water collected on a gathering ground and led into a reservoir, and is a very common source of supply. The purity of the water depends on the nature of the gathering ground, but as a rule it is a good water, and if carefully filtered is clear and wholesome. The water from surface wells and springs is used chiefly in isolated houses and small villages. The purity of the water is influenced by the depth of the well, the amount of pollution of the soil by organic matter, and the construction of the well itself. Shallow well water is always to be looked upon with suspicion, especially if the well is not properly steined. The water is as a rule cool and clear and pleasant to taste. The water from deep, or artesian, wells, is pure and sparkling, but may be hard (*q.v.*) Water is also obtained from rivers, and in London the water supply is chiefly from this source. If no sewage is allowed to enter a river, and if suitable filters are provided, such water is as a rule satisfactory; but if any sewage pollution exists, more especially at a short distance from the intake, the supply must always be looked on with suspicion. In times of flood also the water is highly charged with vegetable matter, and the usual filtration is not sufficient to render the water fit for drinking purposes.

FILTRATION OF WATER.—Artesian well water is supplied direct to the consumer, as it requires no filtration; but as a rule all other supplies to towns are filtered before distribution. The filtering medium is fine sand and gravel, the thickness of each layer varying according to the quality of the water to be filtered. The real filtering medium is, however, the fine scum which forms on the top of the sand, although a certain amount of oxidation takes place in the water in its passage through the layers. The amount of water passing through these layers varies very much, and opinions differ as to the permissible amount, the minimum being 5 gallons, and the maximum 25 gallons per hour through each square yard of surface. *See* FILTERS *and* FILTRATION. For domestic clarification of water there are numerous filters in use, such as the ordinary carbon filter, Bischoff's Filter, and Maignen's Filtre Rapide; but for true filtration either the Berkefeld or the Pasteur-Chamberland filter is necessary. *See* CARBON FILTERS. Water for drinking purposes must not be too hard, especially if such hardness is permanent and not temporary, the former being due to the presence of chlorides, sulphates, and nitrates of calcium and magnesium, and the latter to carbonates of calcium. Temporary hardness can be lessened by boiling and by the Porter-Clark process on a large scale. *See* CLARK'S PROCESS. Soft water is better

for washing purposes, not only because it uses less soap, but bcause it has no effect on the texture of materials, which undoubtedly a hard water has. The amount of water necessary for household purposes varies according as a house is supplied with water closets and baths or not. Without these 10 to 12 gallons per head per day are enough, but with them 20 to 25 gallons are necessary. In manufacturing towns over 30 gallons are required. Where water is derived from a public supply, a storage cistern becomes a necessity, and this should be large enough to contain sufficient water to supply the household for 24 hours, and should be in such a position that it can be easily cleansed. It should also be fitted with a close fitting cover, and should be cleansed at least once every six months. All houses should in addition be supplied with a draw off tap from the rising main. The effects of drinking impure water are very serious, as if such water is polluted with specific germs, epidemics may occur. The specific diseases most frequently caused are cholera and typhoid fever.

SITE AND STRUCTURAL ARRANGEMENT OF HOUSES.—Too much importance can hardly be given to the selection of a site for erecting a house. In large towns and, generally speaking, in places where houses are aggregated together, it is frequently impossible to make a selection; but arrangements can be made on nearly all sites to ensure a healthy dwelling. The first consideration is the nature of the soil. Houses erected on the hard primitive rocks should theoretically be the most healthy, the next being the gravels, followed by sandstone, and, lastly, clay soils. Roughly speaking, the more moisture contained in the soil the less healthy is the site; but other circumstances enter into the question which must be considered, more especially the question in gravel soils as to whether such soil is virgin or not, and whether it has been heavily manured or not. The manuring of land, useful and necessary for agricultural purposes, makes the site, at least for some time, not a desirable one, owing to the amount of decomposable organic matter in such manure. Land also which has been made up with house refuse, road slop, and other refuse, is a most undesirable site, and should never be used as such, at least until all such decomposable matter has been completely removed. The subsoil under all houses, with the exception of those built on hard rock, should be drained by means of open jointed pipes, and the water should either flow into a receptacle some distance from the house, into the nearest ditch, or, in towns, into the general drainage system, with the intervention of a proper and special disconnecting trap. In addition, the whole site should be covered to a depth of at least 6 in. with proper cement concrete, so as to prevent the entry into the house of ground air, or the air in the interstices of the soil. In the erection of a house in the country it is possible to take the aspect into consideration, the best aspect being either south-east or east, preferably the former. Bedrooms especially should face the south-east, and living rooms the north-west, thus ensuring that sunshine shall permeate all the rooms of the house. If a house faces south, then the rooms on the north side get no sun, while those on the south get too much. In the internal structural arrangements of a house, the points to be considered, in addition to those already dealt with, are the position of the water closets, the bathroom, cistern, and sinks. All these should be in such a position that the waste pipes can be taken at once outside. The cistern should be placed in the roof and should be readily accessible. The walls, whether built of stone or brick, should have a good damp proof course above the level of the ground. This should on no account be omitted, as if damp does occur when the house is built it is a difficult matter to insert it. The damp course may be composed of slate, Doulton's ventilating air bricks, or other impervious material. The space between the concrete and the under surface of the floor should be well ventilated, so that there may be a free current of air under the whole house. Neglect of this may be the means of giving rise to what is erroneously called "dry rot," which is due to the growth of a fungus. When once the fungus obtains a hold on the woodwork it is most difficult to eradicate, and it may eventually be necessary to remove all the woodwork before a cure is effected. The thickness of the walls of a house is regulated in London by the London Building Act; but the 9 in. wall, common in London, although satisfying the requirements of such Act if the building is less than 30 ft. high, and does not comprise more than two storeys, is not quite satisfactory from a sanitary point of view. Bricks do not by any means make an impervious wall, and to keep the house free from damp all the outside walls should be hollow. The hollow, which may be 1 or 1½-in. wide, may be filled with pitch or cement. The roof should be covered first with wood, then with felt, and then with slates or tiles. Roofs are frequently made with slates or tiles without wood or felt put underneath, but this makes the top rooms of a house cold in winter and warm in summer. There should be a ventilated air space between the ceilings of the top rooms and the roof itself, the ventilators being in such a position that they can be opened in summer and closed in winter. The size of the rooms in a house will depend largely on circumstances, but no room should be less than 8 ft. high or have a less capacity than 1,000 cubic ft. Every room should be provided with a window and fireplace, so as to ensure satisfactory ventilation. All pantries, larders, and rooms used for the storage of food should be dry, well lighted, and ventilated. Wire gauze at least ¼ in. gauge should be used in window openings to prevent the entrance of flies.

DISPOSAL OF THE DEAD.—Every year this question becomes a more serious one. In view of the fact that the average number of deaths every year in England and Wales during the last ten years is over 550,000, it will be seen that serious consequences might arise if the disposal of the dead were not carried out satisfactorily. In this country there are only two methods of disposal, *viz.* earth burial and cremation, the former being very much the more frequent. In the choice of a cemetery the important points to be considered are the nature of the soil and the necessity of sub-soil drainage. The best soil for a cemetery is a porous, gravelly, or sandy soil, while clay is the worst. The more porous the soil is the more speedily does decomposition set in, and the products of such decomposition are more quickly resolved into harmless elements. The grave should not be more than 9 ft. deep, and the whole graveyard should be drained to this depth. The drainage should be run into the nearest sewer, or if into a stream, care must be taken that the water from that stream is not used for drinking purposes. The Regulations of the Home Office state that there must be 1 ft. of earth above each coffin in a grave, and that it shall be at least 4 ft. below the surface of the ground. There is no doubt, however, that decomposition proceeds more rapidly the nearer the surface the decomposing material is, and a body say 18 in.

from the surface of the ground would possibly be more quickly destroyed than one 4 ft. To prevent any nuisance, however, the regulations have made the depth 4 ft., and the regulations also state that any grave is not to be opened except for the burial of members of the same family for fourteen years. The coffins should be made so that the natural process of decay can go on rapidly, and for this purpose they should be made of light and porous material, as wickerwork or ordinary pine. The use of oak, hard wood of all kinds, and especially lead coffins should be discontinued, as they only hinder the processes which must eventually take place. Vaults of any description should not be permitted. The more quickly the earth comes into contact with the body the better, and any means which retards this should not be allowed. In a clay soil decomposition may be retarded for years, and in some cases the substance known as adipocere is produced. Cremation means the destruction of the body by fire, and in a properly constructed crematorium this can be carried out in two hours without the production of a nuisance. Only one objection besides a sentimental one can be raised to this mode of disposal of the dead, and that is, that it is possible for death from poisoning to take place and the body afterwards cremated, thus leaving no trace of poison. This difficulty, however, can in nearly all cases be surmounted by the authorities insisting on a medical certificate of death signed by two medical practitioners instead of one, and of post mortems being insisted on in any suspicious cases.

Removal of Waste Matter. — The waste matter which must be removed from houses may be classified as follows: (1) Slop water, waste water from sinks and baths; (2) excreta; (3) house refuse. It is also necessary to make some arrangements for the collection of rain water. For the removal of slop water, etc., there must be either proper sinks and pipes connected with the drains or cesspools, or the slop water can be collected in pails and thrown over the land. Excreta may be disposed of by means of water closets connected to the drains or cesspools, or the dry earth system may be adopted. House refuse is either collected by the sanitary authority or may be disposed of by the householder on adjacent land.

Sewerage and Drainage. — In towns and villages with a sewage system adequate means of drainage can be provided by means of proper pipes, traps, and connections. Sanitary authorities are empowered to make byelaws which shall state the size, fall, nature of traps, material, and means of ventilation of such drains. Every drain must be of adequate size, and must be constructed of stoneware or cast iron pipes. The diameter of the drain pipe will depend on the size of the house, but must be at least 4 in. For an ordinary house of six or eight rooms with bathroom this diameter is sufficient, but in larger houses it is necessary to use pipes with a diameter of 6 in. The drain must have a sufficient fall to the sewer, and this fall ought to be equal on the whole length of the drain. A 4 in. drain should have a fall of 1 in 40, a 6 in. drain of 1 in 60, and a 9 in. drain of 1 in 80 at least; but it is very desirable to have more than the above. A useful formula to remember is that each length of 2 ft. pipe should have a fall of half an inch, which is equal to a fall of 1 in 48. This amount of fall renders the drain self-cleansing. The whole of the drains must be laid on a bed of concrete 6 in. thick, and in a 4 in. drain 12 in. broad, and a 6 in. drain 18 in. broad. The drain should also be covered with concrete. With cast iron pipes it is not necessary to use concrete on the top, but the pipe should be laid on a concrete bed. The joints of cast iron pipes should be at least 2½ in. in depth, and made with molten lead, properly caulked. The joints in stoneware pipes must be made with cement. All drains should be tested with water, and should be able to withstand a pressure of at least 2 ft. head of water. Where necessary proper traps must be provided, the most important of these being the intercepting trap between the drain and the sewer. This should be placed in a manhole as near as possible to the main sewer, and should be self-cleansing. The trap must be provided with a cleansing eye and stopper, so that if necessary that part of the drain to the sewer can be cleansed. All rain water pipes should discharge over trapped gullies. The soil pipe must be constructed either of solid drawn lead or of heavy cast iron. The former should only be used if the soil pipe is inside the building. For a 4 in. drain pipe the lead should weigh not less than 74 lb. per 10 ft. length, and for an iron pipe the weight should be 54 lb. for every 6 ft. length, and should be $\frac{3}{16}$ in. in thickness. The lead pipe should have proper wiped plumber's joints, and the iron pipe should have socket joints made with lead properly caulked. The soil pipe, which must be 4 in. in diameter, should be continued upwards to a height of at least 3 ft. above the roof, and as far as possible from any windows or openings into the house. All pipes from sinks and baths should be of lead, efficiently trapped by a syphon trap, and the liquid from them should discharge into a trapped gully. All joints of these lead pipes must be proper wiped joints and not slip joints. The drain itself must be ventilated by means of an air inlet, which is generally placed at the manhole in front, and by outlets, one of which may be the continuation of the soil pipe and the other a special pipe 4 in. in diameter at the highest point of the drain. Traps are of various kinds, but the simplest is the ordinary syphon trap at the outgo of sinks. It is made by bending the lead pipe like the letter S, the lower bend of the letter forming the water seal. Numerous varieties of traps are on the market of a satisfactory character, but the old fashioned dip traps, bell traps, lip traps, and D traps must not be used. The waste pipes from kitchen sinks frequently become offensive, owing to the deposit of greasy matter in the interior. The best way of avoiding this is to use plenty of hot water and to occasionally cleanse with hot water and a strong alkali, as carbonate of soda crystals.

Water Closets.—In recent years great improvements have taken place in the construction of water closet apparatus. The patterns of closet pans and traps now recommended are of much simpler construction, are easier cleansed, and do not readily get out of order. These should be constructed of earthenware, the pan being of such shape and capacity that all excreta shall fall directly into the trap, which is to be an efficient syphon trap and must have sufficient seal, so that sewer gas cannot find its way into the water closet itself. There are numerous forms of water closet apparatus in the market which comply with the above principles, but there are still a number of closet apparatus in use which do not. The following are some of the apparatus in use: Valve closets are good closets if used carefully and if of good type. They require a flush of at least three gallons of water, and, as the apparatus is complicated, are apt to get out of order. Washout closets were at one

time much used, but are not satisfactory. Washdown closets are the best, and variations of this type are numerous. By far the great majority of closets erected have washdown pans and traps. The old hopper closet with spiral flush may still be seen, but this pan is very difficult to cleanse, and in poor class property is a continual source of nuisance. The short hopper pan with rim flush is quite a satisfactory closet for ordinary use, and is cheap and easily cleansed. The junction between the stoneware trap and the iron or lead soil pipe must be properly made with Portland cement if the soil pipe be of iron, and if of lead a flanged brass thimble must be inserted, the joint between the thimble and the stoneware being made with Portland cement, and between the lead and brass there must be a wiped or overcast metallic joint. If an iron pipe is joined to a lead pipe, there should be a brass thimble, and the joint should be made of lead and properly caulked. If one closet discharges into the same soil pipe as another at a lower level, an anti-syphonage pipe must be inserted to prevent the unsyphoning of the trap of the water closet. Such pipes are, as a rule, about 2 in. in diameter, and are taken from the top of the traps of the water closets and connected with the soil pipe above the higher water closet. Water closets are flushed either from a large cistern with check valve or by means of a small water waste preventing cistern of a capacity of 2 or 3 gallons. The former is now only used with valve closets, and the latter to all other kinds of water closets. These cisterns are of various patterns, and act by displacement or syphonage. Needless to say, no water closet should be supplied direct from the main without the intervention of a cistern, and no water closet should be supplied from the same cistern that supplies water used for drinking purposes. Trough closets, although at one time popular for schools, are now being done away with, as they are difficult to keep clean. Slop closets, where slop water is collected in a tank and made to discharge automatically, are used in some provincial towns; but, except that there is a saving of water, there is no other advantage. When no sewage system exists, the drains may discharge into a cesspool, which should be quite impervious and situated as far as possible from the house. It should also be cleansed periodically, and the rain water from the house should be collected separately, otherwise the cesspool will require very frequent emptying. In the dry system of removal of excreta, earth closets, pail closets, or midden privies are used, but these require careful supervision, so as to prevent nuisance. Earth closets are the most satisfactory if supplied with dry garden mould. The contents of these may be used in the garden for manure, or, if in town and collected by the sanitary authority, may be mixed with a certain proportion of ashes and sold to farmers for manure. HOUSE REFUSE consists of ashes from fires, vegetable and animal refuse, sweepings from rooms, etc. The best way to get rid of a large proportion of this is for each householder to burn his own refuse, which can easily be done in a modern kitchener grate, leaving only dry ashes, which may be utilised in the garden. This in most cases is not, or cannot, be done, and consequently a large expenditure is required in towns to remove such refuse. The refuse must be kept in a proper dustbin and covered, and should be removed at least once a week. In flats and tenement dwellings daily removal is a necessity. After collection such refuse is used either to make up low-lying land, used as a manure, or burnt in a destructor, the clinkers formed being used to make up roads, etc.

SEWERS.—Main sewers which carry off the water from house drains vary in size from 9 in. to 10 ft. Pipes are used if the diameter is not more than 18 in., but above that brick sewers are necessary, and these ought to be oval in section. The rate of flow in sewers should not be less than 2·5 ft. per second, and to ensure this the sewers should have a fall of 1 in 200 for 12 in., to 1 in 750 for a sewer 5 ft. in diameter. These sewers must be ventilated every 100 yards, and there may be either manholes in the centre of the roadway or pipes may be laid from these to shafts about 30 ft. high against buildings if possible. Various methods have been tried to abate nuisances from these ventilators, but none have so far proved very successful under all circumstances. One of the most successful is Reeves' system, where deodorisation certainly takes place by means of the production of free oxygen. The following formula given by L. Parkes is used to calculate the discharge for a sewer:

$V = 55\sqrt{D \times 2F}$, and $Q = V \times A$.
V = Velocity in feet per minute.
A = Sectional area of current in square feet.
D = Hydraulic mean depth.
F = Fall in feet per mile.
Q = Cubic feet of water discharged per minute.

SEWAGE DISPOSAL.—The methods adopted are: (1) Discharge of sewage into the sea or the nearest stream either in a crude state or after previous treatment by filtration, subsidence, or a combination of both with chemicals. (2) Discharge of sewage on land either by irrigation or by intermittent downward filtration. (3) Purification by means of septic tanks, the effluent being discharged into the nearest stream or into the sea. The first method is the one most frequently adopted, as, if there is no previous treatment of the sewage, it is probably the cheapest. The following are some of the patent processes:

Scott's . .	Lime and clay.
Sillar's A.B.C. .	Alum, blood, clay, and charcoal.
Coventry process	Alum, iron, and lime.
Anderson's. .	Crude sulphate of alumina.
Acton process .	Ferrozone and polarite.
Amines' . .	Lime and herring brine.

The SEPTIC TANK SYSTEM (*q.v.*) has only recently been put in operation, and, so far, in smaller towns has proved satisfactory. From a sanitary point of view it is the least satisfactory system. The disposal of sewage on land, if properly carried out, is the best; but this is only possible where suitable land can be had at a reasonable distance. SEWAGE FARMS, as they are called, have proved fairly successful, and, with the exception of cereals, crops such as rye grass and root crops can be grown satisfactorily. If chemicals are used, there is always a difficulty in disposing of the sludge, which has little or no manurial value. The chemicals used are alum; lime, either alone or in combination with phosphate of calcium or clay. The difficulties in dealing with sewage will be very much lessened if no rain water is allowed to discharge into the house drains, and this separate system has been adopted in several towns.

DISINFECTANTS AND DISINFECTION: Many diseases are caused by germs or bacteria, and it is necessary after the occurrence of one of these diseases for disinfection to be carried out to prevent further infection. Popularly, the term disinfectant is applied to a large number of substances which do not destroy such bacteria, and it is therefore necessary to clearly

distinguish between deodorants, antiseptics, and true disinfectants. DEODORANTS only destroy any offensive odour; ANTISEPTICS merely arrest the growth of germs; while true DISINFECTANTS absolutely destroy the germs, so that they become harmless. Numerous chemicals are used for disinfecting purposes, but only very few are true disinfectants, and in nearly all cases these are very poisonous salts. The most commonly used are corrosive sublimate, carbolic acid, and preparations of creosote; and to these may be added chinosol, a synthetic product. For ordinary use carbolic acid in a solution of 5 per cent. (1 in 20) is satisfactory; but this strength has a very deleterious action on clothing and bedding, and the same applies to most of the creosote preparations. Corrosive sublimate in the strength of 1 in 1,000 is a good disinfectant, but it is not advised, as it is extremely poisonous and destructive. Permanganate of potash, 5 per cent., is also a useful disinfectant, but in this strength is not suitable for disinfecting clothing. Chlorinated lime, or chloride of lime, as it is popularly called, in 5 per cent. solution, is a useful disinfectant, but has itself a disagreeable odour. The best and most satisfactory method of disinfecting bedding and clothing is by means of steam in a closed chamber, and all sanitary authorities should possess a suitable steam disinfecting apparatus. Washington Lyons' apparatus consists of a cylinder with a double casing or jacket. Steam is first introduced into the jacket, thus preventing loss of heat by condensation. The goods to be disinfected are placed in the chamber, and a door, which is lined with rubber seating and secured by screw clamps, is closed. Steam is then admitted to the chamber until the pressure reaches about 20 lb to the square inch, giving a temperature of about 260° F. The steam is superheated by having the pressure in the jacket higher than in the chamber itself. The articles are kept in the chamber for about ten minutes before the steam is allowed to escape. The door at the other end of the chamber is then opened and the goods removed. The whole apparatus is constructed so that when *in situ* one door opens into one room and the other into another, thus ensuring that the goods when disinfected shall not again come into contact with other infected articles. Other disinfectors are Thresh's, Reck's, and the Equifex, made by Defries & Co. In any of the above apparatus, if ordinary precautions are taken, no damage need be done to ordinary bedding, blankets, and wearing apparel. Leather and furs cannot, however, be disinfected by steam, but may be by dry heat cautiously applied. Articles which have previously been exposed to sulphur fumigation should not be disinfected by steam, because sulphuric acid is formed, and consequent destruction to the material ensues. It is also to be remembered that steam acts as a mordant, and permanently fixes any stains such as those caused by albuminous material, blood, food, or urine.

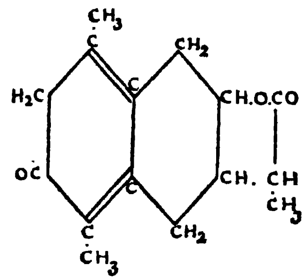
FUMIGATION: In addition to disinfection of bedding, clothing, etc., by steam, it is advisable in cases of infectious disease to fumigate the room, and this may be done either by means of sulphur or formalin. The former is better if the room is infected with vermin, as the latter has no effect on these; but in the majority of cases formalin is the most satisfactory agent to use. The strength of sulphur is usually 1 lb. to every 1,000 cubic feet of space, while in the case of formalin 25 to 30 formalin tablets are necessary for the same space. Formalin has no deleterious action on brass, delicate fabrics, or colours; while sulphur, especially if there is any moisture present, may injure these substances. After fumigation the room should be freely ventilated, and sunshine should be allowed to permeate the whole room if possible. The walls, ceiling, and floor of the room may be sprayed with a 40 per cent. solution of formalin, and the wall paper should always be stripped off. This is more especially necessary after cases of scarlet fever and diphtheria. For a more complete study of the subject the following works on hygiene may be consulted: Stevenson and Murphy (3 vols.), Hamer, Louis Parkes, Whitelegge, and Wynter Blyth.—P. C. S.

Sanserif (*Typog.*) A letter without serifs, as M.

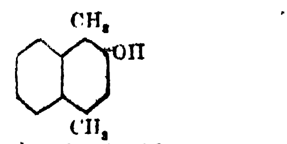
Santalum (*Botany*). An East Indian tree, *Santalum album* (order, *Santalaceæ*), yields SANDAL WOOD (*q.v.*)

Santonin (*Botany*). A powerful drug prepared from the dried immature capitula (or flower heads) of *Artemisia maritima* (var. *Stechmannia*; order, *Compositæ*).

Santonine (*Chem.*) Probable formula

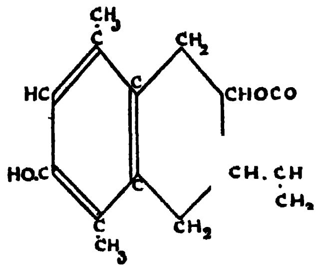


Forms white shining leaves or trimetric tables: melts at 170°; 1 part dissolves in 5,000 parts water at 17·5°, in 250 parts at 100°; much more soluble in alcohol: easily soluble in chloroform; its solutions are lævorotatory. The optically active forms show triboluminescence. It is used in medicine for round worms and threadworms. Poisonous: an overdose affects the vision, causing objects to appear violet, greenish, then yellow. It occurs in wormseed (the unopened flower heads of various kinds of Artemisia). The wormseed is treated with a thick milk of lime, water added and violently shaken; the calcium santoninate is extracted at 65° to 70° with alcohol; and the alcoholic solution decomposed with hydrochloric acid. The crude santonine is purified by recrystallising from alcohol, using animal charcoal first to decolorise it. It must be dried in absence of light. Santonine is the lactone of santoninic acid; it is also a ketone, as it forms both a hydrazone and an oxime. That it contains a naphthalene ring and a three carbon atom side chain is shown by the fact that santoninic acid and other acids derived from santonine yield dimethyl-β-naphthol and propionic acid—

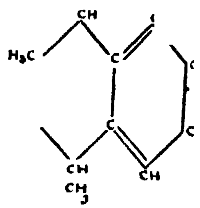


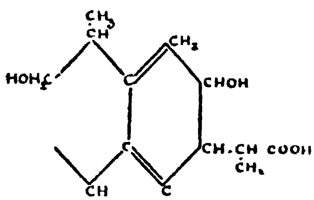
and CH_3CH_2COOH, when fused with caustic potash. When santonine is exposed to light it turns yellow, forming an isomeric compound called chromosantonine. Another isomer of santonine known as desmotroposantonine is formed when santonine

dissolved in concentrated hydrochloric acid is allowed to stand. When purified by washing with hydrochloric acid and recrystallisation from alcohol it forms shining needles, which melt at 260°, and are not changed by light; neither does it yield an oxime or a hydrazone; but it yields an acetyl derivative. It is probably the enol form of santonine:



When light acts on a solution of santonine in dilute acetic acid, Photosantonic acid is formed; when light acts on its solution in dilute alcohol, Isophotosantonic acid is formed. The fomulæ of these substances are respectively





Sap (*Botany*). A general term for the fluids contained in the tissues of a plant; the circulating fluids which convey nutritive material.

—— (*Met.*) The unaltered core of iron in the bars of blister steel, made by the cementation process at "spring heat."

Saponification. Generally in a technical sense means the chemical changes which result when soap is made by the action of alkali on fixed oils or fats; but it also includes other changes in which compound ethers are broken up. At one time the term was confined to the action of alkalies (including lime), but it now includes the agency of sulphuric acid, superheated steam, and enzymes peculiar to certain seeds. *Cf.* HYDROLYSIS.

Saponine (*Chem.*) A glucoside. It is a white amorphous powder soluble in water, and having the property of giving a lather to water when shaken. It occurs in many plants, and especially in the common soapwort. Hydrolysed by dilute acids to glucose and a crystalline substance sapogenin, constitution unknown.

Sapphire (*Min.*) The blue variety of Corundum (*q.v.*) The ordinary sub-variety is known as Oriental Sapphire; that with a reddish or bluish reflection is called Girasol Sapphire; and the sub-variety with a pearly reflection is the Chatoyant or Opalescent Sapphire. The chief localities for Sapphires are Ceylon, Pegu, Bohemia, near Expailly in France, and New South Wales. It is highly prized as a gem stone.

——, **Brazilian** (*Min.*) This is a blue variety of Tourmaline (*q.v.*); the colour is lighter than the true sapphire, and the stone is less hard. *See* PRECIOUS STONES.

Saprophyte (*Biology*). An organism which subsists on decaying organic substances.

Sap Wood (*Botany*). The new wood next to the bark of a tree. It is inferior in value to the heart wood, from which it is usually easily distinguished by colour, etc.

Saracenic (*Architect.*) The architecture of various countries during the period in which they were under the influence of the faith of Islam. It can be divided into Arabian, Moorish, Persian, Indian, and Turkish. These styles, though differing in many respects, have much in common. *See* MOORISH.

Sarcine (*Chem.*) HYPOXANTHINE (*q.v.*)

Sarcolactic Acid (*Chem.*) *See* LACTIC ACID.

Sarcosine (*Chem.*)

$$\begin{array}{l} CH_2NHCH_3 \\ | \\ COOH \end{array} \quad \text{or} \quad \begin{array}{l} CH_2.NH_2CH_3 \\ |\qquad\quad | \\ CO{-}O \end{array}$$

(Methylglycocoll.) Rhombic prisms; melts at 210° to 220°, with decomposition into carbon dioxide, dimethylamine, and other products; soluble in water; heated with soda lime it forms methylamine; acts as a weak base; forms characteristic platinum double salt. It is a decomposition product of creatine (*q.v.*); also formed by boiling caffeine with baryta water. It is prepared synthetically by the action of monochloracetic acid on methylamine:

$$\begin{array}{l} CH_2Cl \\ | \\ COOH \end{array} + H_2N.CH_3 = \begin{array}{l} CH_2NHCH_3 \\ | \\ COOH \end{array} + HCl$$

Sard (*Min.*) An orange brown variety of CHALCEDONY (*q.v.*)

Sardonyx (*Min.*) A variety of Chalcedony having parallel banding of alternate layers of red and bluish white or white. *See also* PRECIOUS STONES.

Saros (*Astron.*) *See* ECLIPSES, NUMBER OF.

Sarsaparilla (*Botany*). Is the dried roots of *Smilax officinalis* (order, *Liliaceæ*), and other species of Smilax imported from Tropical America and the East Indies.

Sash (*Carp. and Join.*) The portion of a window containing the glass.

Sash Bit (*Carp. and Join.*) A long twist bit used for boring sashes.

Sash Door (*Carp. and Join.*) A door having the upper part glazed.

Sash Frame (*Carp. and Join.*) A term sometimes applied to a SASH (*q.v.*), but more properly restricted to the outer frame of a window in which the sashes move.

Sash Tool (*Dec.*) A small brush made of hog bristles, used for painting window sashes. *See* PAINTERS' BRUSHES.

Satarra (*Woollen Manufac.*) An old type of woollen cloth, with fine lines weftways.

Sateen (*Textile Manufac.*) A form of weave used for cotton, woollen, or linen fabrics. Very largely adopted for cotton cloths requiring dyeing, printing, or mercerising. It has a very solid and smooth surface, like satin, of either warp or weft. The effect is produced by the rearrangement and regular distribution of the intersections in such a way that they are hidden from view. A WARP SATEEN is a cloth with a warp surface and a greater proportion of warp threads than weft; WEFT SATEEN is the reverse.

Satellite (*Astron.*) A term applied to the smaller bodies revolving round the planets or stars. Thus the Moon is the satellite of the Earth.

Satin. A plain silk fabric presenting an even, lustrous, soft surface, obtained by the long flushing or floating of the warp threads on the face of the work.

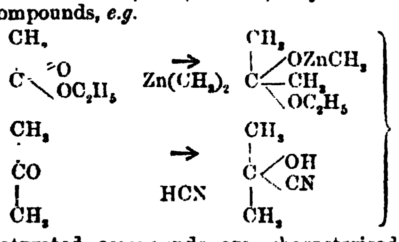
Satin Leather (*Leather Manufac.*) Leather finished with bright black polish to resemble satin. It is finished quite smooth, without grain marks.

Satin Spar (*Min.*) This term is used for the finely fibrous varieties of Calcite, Aragonite, or Gypsum; in all three cases the mineral is in veins with the fibrous structure running transversely. All are white or greyish white (rarely pink in the case of Gypsum), and show a satin-like surface when polished.

Satin Walnut. *See* WOODS.

Satin Wood. *See* WOODS.

Saturated Compounds (*Chem.*) Compounds in which each element is united to monovalent atoms or groups of atoms, the number of which equals the maximum valency of the element. Thus if oxygen is regarded as divalent, then water is a saturated compound; but if oxygen is regarded as tetravalent, then water is an unsaturated compound and should form additive compounds; a very large number of compounds crystallise with one molecule of water. On the above definition, acetic acid and all compounds containing a carbonyl group must be regarded as unsaturated, and, in fact, they all form additive compounds, *e.g.*



Saturated compounds as regards carbon.

Saturated compounds are characterised by their inability to enter into reaction unless an atom or atomic group, or more than one atom or atomic group, can be replaced by another atom or atomic group. Thus marsh gas can only react by having one or more hydrogen atoms replaced by other atoms.

Saturated Steam. Steam in the condition of a saturated vapour; a diminution of volume without change of temperature (*i.e.* isothermal compression) or a fall in temperature causes condensation to commence. *See also* VAPOUR PRESSURE *and* STEAM.

Saturation (*Heat*). A term applied to the condition of a vapour when it is at the maximum density and pressure which correspond to its temperature; condensation commences if the vapour be compressed, the pressure remaining constant. *See* VAPOUR PRESSURE.

——, **Magnetic.** When a magnet has been magnetised as strongly as possible, it is said to be SATURATED; the material of the magnet becomes less and less permeable as the magnetising force is increased, and the total number of lines of force which can be caused to pass through the iron thus tends towards a limit. In good wrought iron this limit is practically reached when the value of the magnetic induction B is about 20,000 lines per square centimetre; in cast iron the number is about 12,000. Higher values have, however, been obtained in laboratory experiments.

Saturation of the Air (*Meteorol.*) When the atmosphere contains so much moisture that it cannot carry any more it is said to be saturated.

Saturn, Planet (*Astron.*) Remarkable for possessing what appear to be three flat rings surrounding the planet; round the outside of these rings move eight satellites. Distance from sun, 886,000,000 miles. Diameter, 73,500 miles. Periodic Time, about 29½ years.

Saunders Blue (*Paint*). The term is a corruption of the French *Cendres Bleues*. Ultramarine ash.

Savannah. A plain or tract of land devoid of trees, but covered with other forms of vegetation.

Saw. *See* SAWS.

Saw Bench. The table or support of a machine saw, on which rests the material that is being cut. The term is most commonly applied to the table of a circular saw.

Saw Block (*Typog.*) A piece of wood similar to a carpenter's mitre block, with the addition of a right angle cut, on which furniture is cut to required lengths.

Sawdust. This is used for various cleaning purposes; for mixing in certain patent fuels; in moulding, to give porosity to the moulds; as a packing material, in the manufacture of oxalic acid, and for various other purposes in the arts and trades.

Saw File. A file specially made for sharpening saws. The commonest type is of triangular section, but files of other shapes are also used for sharpening special kinds of saws.

Saw Filing Machine. A machine used for sharpening large saws, such as band saws. The saw is fixed in a suitable holder, and files moved by the machine act upon the teeth in succession.

Saw Frame (*Carp., Eng., etc.*) A frame in which a thin or narrow shaped saw is fixed, being kept in tension by the frame. Hack saws and bow saws, fret saws and certain forms of machine saws are thus supported. *See* SAWS.

Saw Gullet. The space between two teeth. This space has to be enlarged by filing, as the teeth wear away through repeated sharpening; the process is termed GULLETING.

Sawing In (*Bind.*) Making slight indentations in the back of a book previous to sewing the sections together. The indentations are for the purpose of receiving the cords or bands (*q.v.*) to which the book is sewn, and are made by a tenon saw or a machine. In the case of *flexible binding* the back of the book is not sawn, the bands lying outside. *See* SEWING.

Saws (*Carp. and Join. Eng., etc.*) Saws may be divided into two main classes: (1) those used by hand, and (2) those driven by machinery. Of the first class, the HAND SAW is the most important; the blade is about 2 ft. long, sufficiently thick to ensure stiffness when in use, tapering in form, and having from 5 to 7 teeth to the inch. Of the same type are the RIP SAW, with large teeth, for cutting along the grain of wood, and the HALF RIP (these have 3 or 4 teeth to the inch); and the PANEL SAW, used in cutting tenons, etc., and having from 7 to 10 teeth per inch. CROSS CUT SAWS have a blade slightly curved or bellied along the cutting edge, and a handle at each end, requiring two operators; they are used in felling trees and in cutting across large balks and logs. For cutting across the grain of wood in small work the TENON SAW is used. The blade is very thin, and is stiffened by a rib or back of brass or steel; from this fact the term BACK SAW is sometimes applied. It has 10 or 12 teeth to the inch. A DOVETAIL SAW is a similar saw with still finer teeth, usually 14 to 18 per inch. For cutting along a curve or in a very narrow space, a saw with a very narrow tapering blade (without a back) is used; of this form are the COMPASS SAW, PAD SAW, and KEYHOLE SAW. When the blade is very narrow or very thin, it does not possess sufficient strength to enable it to be used without breaking, and is therefore supported in a frame, by which the blade is kept in tension and thereby prevented from sudden bending and consequent breakage. The BOW SAW is the type most used, in which the saw is fixed in a rectangular hinged frame of wood, and kept in tension by a twisted cord. A FRET SAW for hand use also has a rectangular frame, but made of steel, and the fine saw is kept sufficiently tight by the elasticity of the frame itself. A HACK SAW usually has a blade ⅝ or ½ in. wide, kept in tension in a metal frame; it is used for sawing metal, the blade being of hard tempered steel. Hack saws are not usually sharpened, as in most cases the blade breaks before its cutting power is exhausted, and a new blade is fitted.

The most important types of MACHINE SAW are the CIRCULAR SAW, BAND SAW, and JIG SAW, or JIGGER. The former is a circular disc of steel, varying in diameter from a few inches to several feet, according to the use for which it is required. The most important application of the circular saw is the cutting of logs and balks into deals, boards, etc., but some types are used for cross cutting. A GROOVING SAW is a circular saw having a thick blade projecting a small distance only above its table, and is used for rapidly cutting long grooves in wood. A BAND SAW is wholly distinct from all the preceding types. It consists of a long ribbon of steel, having teeth on one edge, the ends being brazed together to form an endless band. This band runs over revolving pulleys, so that the motion of the teeth is always in one direction; it has a great variety of uses, and is especially useful in rapidly cutting curved work. Band saws may be adapted for cutting metal as well as wood. A JIG SAW consists of a narrow straight blade, fixed in a frame, by which it is kept in tension; this frame is given a reciprocating motion by machinery. Two or more blades are often fixed in one frame, and the saw is then used for cutting simultaneously a number of boards from a single deal or log. Fret saws and hack saws are occasionally driven by machinery, a fret saw driven by foot power being a familiar tool in the workshops of amateurs. Various other types of machine driven saws are also made for special uses, but they usually follow one or other of the above types.

Saw Setting. If the teeth of a saw lay entirely in the plane of the blade, the saw would jam in the cut or kerf. To prevent this, the teeth are bent alternately to right and left by means of pliers, a punch, or a tool with slots fitting the teeth, termed a SAW SET.

Saw Sharpening. The formation of the cutting edge on the teeth of a saw, as distinguished from setting and gulleting.

Saw Spindle. The axis or shaft on which a circular saw is mounted and by which it is driven.

Saw Table. A SAW BENCH (*q.v.*)

Saxhorn (*Music*). A family of brass wind instruments invented by M. Sax, a Belgian, about 1840. *See* p. 437.

Saxifragaceæ (*Botany*). An order which includes the genus RIBES, the Currants (*R. rubrum*, the Red Currant; *R. nigrum*, Black Currant; *R. grossularia*, Gooseberry), and a number of garden plants.

Saxon Architecture. *See* ANGLO-SAXON ARCHITECTURE.

Saxophone (*Music*). A family of brass wind instruments invented by M. Sax, and played by means of a single reed. *See* p. 432.

Sc (*Chem.*) The symbol for SCANDIUM (*q.v.*)

Scab (*Foundry*). A place on the surface of a casting where the fluid metal has penetrated the surface of the mould, forming a lump or projection, which may be composed either of sound metal or of metal mixed with sand, and consequently unsound.

Scabbard (*Arm.*) The sheath of a sword. *See* ARMOUR.

Scabbling (*Build.*) Roughly reducing stones (at the quarry) to the desired shape.

Scabby (*Typog.*) A term used to describe work unevenly printed, owing to irregular distribution of ink and consequent patchy appearance.

Scabellum (*Architect.*) A form of pedestal used as a support for a bust or statue.

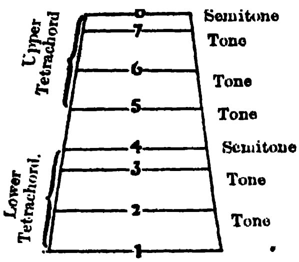
Scagliola (*Dec.*) An imitation marble composed of the same materials as MAREZZO (*q.v.*); but the process of manufacture is somewhat different.

Scalar Quantity (*Phys.*) A quantity which possesses magnitude, but not direction, as distinguished from a VECTOR (*q.v.*) Mass and density are examples of scalar quantities.

Scale (*Drawing, etc.*) (1) A line (straight or curved) which has been divided in some special manner. (2) A piece of wood, metal, ivory, etc., on which such a scale is drawn. (3) The ratio of the dimensions of a drawing to the corresponding dimensions of the actual object which it represents. *See* SCALE DRAWING.

—— (*Music*). The series of sounds into which an octave is divided. Scales are of two kinds: Diatonic and Chromatic. The DIATONIC SCALE, so called because in performing it the passage is chiefly *through tones*, is of Greek origin, and of two kinds or modes: (1) The Major mode; (2) The Minor mode. The MAJOR MODE consists of two Tetrachords

having the same steps, viz. Tone, Tone, Semitone; and are themselves separated from each other by a Tone. The steps therefore are:



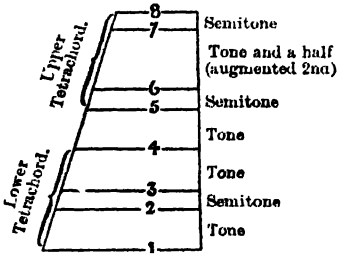
all the intervals being Tones excepting between the 3rd and 4th and between the 7th and 8th sounds, which are Semitones. Because there are between the 1st and 3rd sounds two tones (a Major 3rd), this mode is called the Major Diatonic scale. If C is taken as the starting note to form these steps, the first tetrachord will consist of C, D, E, F, the separating Tone reaching to G, and the second tetrachord consisting of G, A, B, C—all natural notes. Hence this is sometimes called the Natural scale. But if any other note than C be taken as a starting point, sharps or flats (*q.v.*) are required; *e.g.* taking B as a starting or keynote, the first tetrachord is—

| Tone | Tone | ½-Tone |
B C♯ D♯ E

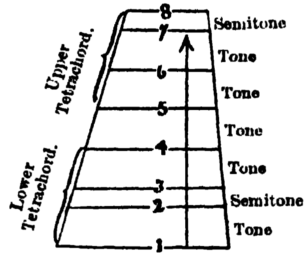
and the second tetrachord—

| Tone | Tone | ½-Tone |
F♯ G♯ A♯ B.

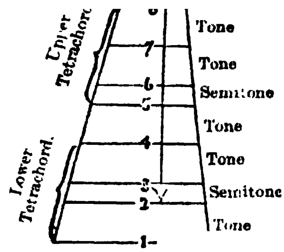
These sharps and flats are placed at the beginning of a piece, and are known as the key signature. For the sharps and flats necessary to each Major scale *see* KEY SIGNATURE (p. 332). The MINOR MODE originally consisted of the same sounds, starting a minor 3rd lower, *i.e.* taking the sixth note as the starting note. Modern music discards this Normal minor mode, except in the case mentioned below, but recognises two forms of the Minor mode: (*a*) The Harmonic form, and (*b*) the Melodic form. (*a*) The Harmonic form, as its name implies, is that employed by parts in progressing from one chord to another, and is the older of the two forms. It only differs from the original minor in having the seventh sound sharpened so as to give a proper leading note, *i.e.* a seventh sound of the scale a semitone only below the eighth. The order of the steps in the Harmonic form of the minor are:



(*b*) To avoid the awkward interval of the augmented second when taken melodically, the Melodic form of the minor scale came into practice, which gives the following order of steps in ascending:



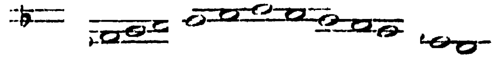
This, however, with the exception of the third sound, is identical with the Tonic major (*q.v.*); and in order to preserve the identity of the Minor mode, the steps of the upper tetrachord are altered in descending to the Normal minor, the order of the steps being:



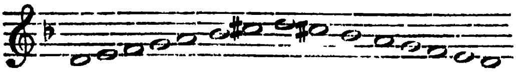
The CHROMATIC SCALE consists entirely of semitones, the octave being divided into twelve steps. There are two forms of the chromatic scale, *viz.* the Harmonic and the Melodic, the difference being one of notation only. The Harmonic form in the Major key consists of the seven notes of the Major diatonic scale with the Minor 2nd, 3rd, 6th, and 7th, and Augmented 4th added; in the Minor key it consists of the seven notes of the Normal minor scale with the Minor 2nd, Major 3rd, 6th, and 7th, and Augmented 4th added. The melodic form of Chromatic scale in the Major key consists of the seven notes of the Major scale, with the addition of a chromatic semitone after the 1st, 2nd, 4th, 5th, and 6th notes in ascending, and, in descending, is identical with the Harmonic Chromatic scale. In the Minor key it consists of the Normal minor scale, with a sharp (or natural) inserted after the 1st, 3rd, 4th, 6th, and 7th notes when ascending, and having exactly the same notes in descending, with the single exception that the Minor 2nd of the key is used instead of the chromatically altered keynote. The following shows the different scales, taking D as the keynote in each case:

Major Diatonic Scale.

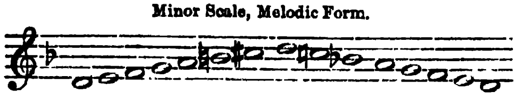
Minor Scale, Normal Form.



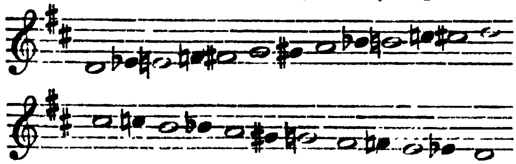
Minor Scale, Harmonic Form.



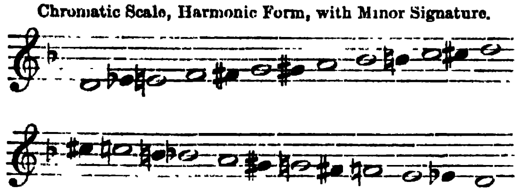
Minor Scale, Melodic Form.



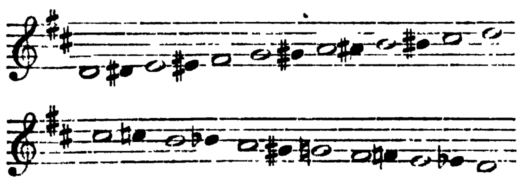
Chromatic Scale, Harmonic Form, with Major Signature.



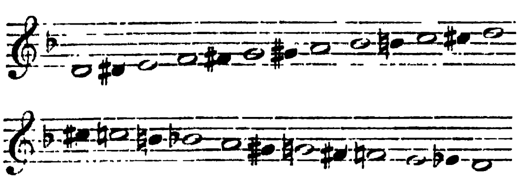
Chromatic Scale, Harmonic Form, with Minor Signature.



Chromatic Scale, Melodic Form, with Major Signature.



Chromatic Scale, Melodic Form, with Minor Signature.



It is not unusual to find incorrect notation in chromatic scales, the reason being that at times it minimises the number of accidentals in a passage. The ancient scales of the Church are shown under MODES (*q.v.*) *See also* KEY *and* KEY SIGNATURES.

Scale (*Trade Term*). (1) Material formed on the surface of an object, *e.g.* oxide formed on wrought iron during forging. (2) Material which has been carried into boilers or tanks suspended or dissolved in the water, and has been deposited on the walls or plates of the vessel.

Scale Board (*Typog.*) An obsolete term describing a material formerly used for obtaining accurate register (*q.v.*) Leads and thin strips of cardboard are now generally employed.

Scale Drawing. Drawing an object to scale means making a drawing in which all the dimensions are altered in the same proportion; the ratio of the actual size of the drawing to the actual dimensions of the object is termed the REPRESENTATIVE FRACTION, or the SCALE, of the drawing.

Scale of Hardness (*Min.*) *See* HARDNESS.

Scale, Thermometric (*Heat*). The division into convenient intervals, termed DEGREES, of a known difference of temperature. This difference is in practice that between the freezing and boiling points of pure water at normal atmospheric pressure. In the scale used in scientific work, the CENTIGRADE SCALE, the two fixed points, as the above two temperatures are called, are marked 0° and 100° respectively; in the English, or FAHRENHEIT SCALE, they are marked 32° and 212°, and in the REAUMUR they are marked 0° and 80°. Thus 100° Centigrade corresponds to 180° Fahrenheit and 80° Réaumur. For conversion from one to another it is convenient to use the following formula, in which F denotes the reading on the Fahrenheit, C the Centigrade, and R the Réaumur scales:

$$F - 32 = \frac{9}{5}C = \frac{9}{4}R.$$

Scaling (*Eng., etc.*) Removal of scale or deposits from a surface, *e.g.* from the inner surface of the plates of a boiler.

Scaling Hammer (*Eng.*) A hammer with a sharp edge, used for SCALING (*q.v.*)

Scandinavian (*Typog.*) A printing machine of the platen principle.

Scandium (*Chem.*) Sc. Atomic weight, 44. A very rare metal occurring in gadolinite and euxenite. The metal has not been obtained. Oxide, Sc_2O_3, a white infusible powder. Sulphate, $Sc_2(SO_4)_3$, forms a double salt with potassium sulphate. Spectrum (spark) is characteristic and very complex. The existence of scandium was predicted by Mendeleeff, and he gave it the name Ekaboron.

Scantling (*Build., etc.*) (1) A sample or pattern, *i.e.* a small quantity. (2) The dimensions of certain building materials, *e.g.* timber, stones, etc., as regards length, breadth, and thickness. (3) Timber less than 5 in. square.

Scapolite (*Min.*) A calcium-aluminium-sodium-chlorosilicate. Composition variable. Tetragonal; colour white, grey, or pale blue or green. It is chiefly found in metamorphic rocks, especially in those of calcareous origin. From Scandinavia, Finland, Greenland, and North America.

Scapula (*Zool.*) The shoulder blade; it is the principal member of the series of structures termed the SHOULDER GIRDLE, to which the fore limbs of an animal are attached.

Scapular, Scapulary (*Cost.*) (1) A narrow band of cloth worn across the shoulders and reaching almost to the feet. It forms part of the dress of certain religious orders. (2) A monastic hood and cloak.

Scarab (*Archæol.*) A gem carved on one side in the shape of a scarabæid beetle, and on the other side engraved as a seal; used by the ancient Egyptians as a seal and amulet.

Scarf Joint (*Carp.*) This term is applied to a variety of longitudinal joints between timbers (*i.e.* timbers fixed to each other in the same straight line). The essential characteristic of the joint is that the two members overlap, each being cut in some special manner, as distinguished from a butt joint, in which there is no overlapping. There is a great variety of scarf joints, differing in the form given to the cut surfaces and in the manner of wedging or keying up the joint.

Scarp *or* **Escarp** (*Her.*) A diminutive of the bend sinister, and half its width.

Scars (*Chem. Tech.*) The clinkers (chiefly sulphide of iron) which form in pyrites burners during the combustion of pyrites for the generation of sulphur dioxide in the manufacture of vitriol.

Scauper (*Engrav.*) (1) A tool used in wood engraving for cutting away the spaces between the lines. (2) A tool used by line engravers. *See* ENGRAVING AND ETCHING.

Scene (*Art*). (1) A landscape or view. (2) One of the divisions of an act of a play. (3) A screen or curtain suitably painted to form the background for the action of a play. (4) The stage with its surroundings.

Scheele's Green. Used as a pigment, though its poisonous nature has gradually prevented its use on wallpapers. It is arsenite of copper. Insoluble in water. Obtained by adding a soluble salt of copper such as the sulphate (blue vitriol) to a solution of potassium arsenite, when the pigment is precipitated.

Scheelite (*Min.*) Calcium Tungstate, $CaWO_4$, containing 70 to 80 per cent. of Tungstic acid. Tetragonal and hemihedral, occurring in lustrous short pyramids in various shades of yellow and brown. Its density is high, 4·5 to 5·0. Brittle. Named after Scheele, the Swedish chemist, who first discovered Tungstic acid in this mineral. From Brandy Gill and Mosedale in Cumberland, Cornwall and Devonshire, Bohemia, Saxony, Hungary, etc. Valuable as a source of Tungstates.

Scherzando, Scherzoso (*Music*). In a playful, jestful manner.

Scherzo (*Music*). A composition of a playful character.

Schiffs' Reagent (*Chem.*) A solution of magenta decolorised by sulphur dioxide; it gives a violet colour with many aldehydes. *See* ROSANILINE.

Schist (*Geol.*) The term schist is applied in France and Italy to any rocks which are fissile or split readily into thin slabs. The term is there used without any reference to the history of the rock, so that what would be called Shale, Plate, Shiver, or Blaes in Britain, as well as flagstones and also slates of all kinds, would there be termed Schist. Here, however, the use of the term is restricted to such rocks as split in certain definite directions in consequence of the development within them, by metamorphic causes, of some scaly silicate, such as mica or chlorite. Schistose structure is, in this sense, always a result of dynamic metamorphism. Any rock may be rendered schistose if it is subjected to powerful earth movements, operating at great depths below the surface and of such a nature as to give rise to a shearing movement, or flow, of one part of the rock over the next immediately below it. It is probably a result of continued physical and chemical changes in which a high temperature and the presence of water are factors of considerable importance in bringing about the metamorphic change. Schistose structure may be developed in any kind of rock, though the term schist is usually understood to imply the absence of any layers or bands containing much crystalline felspar. A rock of this latter kind would be termed a Gneiss (*q.v.*) The mineral character of a schist necessarily varies with that of the original rock affected. Thus, if potash felspar is originally present, as is the case in the arkoses of the Torridonian Rocks, Muscovite is found at the expense of the felspar, and the rock becomes a Muscovite Schist. If some original ferro-magnesian silicates are present, the rock may become a biotite schist or a hornblende schist, as the case may be. Some modifications arise through the temperature prevailing where the schist was in process of formation. Subsequent changes produced by (1) a later rise of temperature, (2) hydrometamorphism, may affect the character of the schist. Thus, if the ferromagnesian silicates are hydrometamorphosed, the rock may become a Chlorite Schist.

Schistose Structure (*Geol.*) *See* SCHIST.

Schleifer (*Music*). *See* ORNAMENTS (6), p. 479.

Schnell (*Music*). The German term for quick, as *Mässig schnell*, moderately quick. The comparative is *Schneller*.

Schneller *or* **Schnelzer** (*Music*). *See* MORDENTE, p. 413.

Schools of Painting. *See* PAINTING, SCHOOLS OF.

Schorl (*Min.*) A black variety of Tourmaline (*q.v.*) It is the commonest variety, and is a common mineral in plutonic and metamorphic rocks.

Schweinfurth Green. Sometimes called Imperial green. A somewhat obsolete pigment. It is an aceto-arsenite of copper obtained by adding acetate of copper solution to arsenious oxide (white arsenic) in water.

Schweitzer's Reagent (*Chem.*) A solvent for cellulose. *See* CELLULOSE.

Sciagraph. The plan of a building drawn in vertical section so as to afford a view of the internal structure.

—— (*Elect.*) A synonym for RADIOGRAPH, a photograph taken by the Röntgen Rays.

Sciagraphy. (1) In astronomy, the method of ascertaining the time by observing the shadows due to the sun, moon, or stars; dialling. (2) In art, the correct rendering of shadows: shading.

Science. "The classification of facts, and the recognition of their sequence and relative significance" (*Karl Pearson*).

Scimitar (*Arms*). A curved sword with the cutting edge on the convex side; a weapon peculiar to Oriental countries.

Scintillation. An expression of no very exact signification, *e.g.* the throwing off of sparks by a hot object, or an appearance of the same kind in the case of a brightly luminous or illuminated object.

Scintillation of Stars (*Astron.*) The light of stars when near the horizon does not appear steady, but scintillates or twinkles. This is a purely atmospheric phenomenon.

Sciolto, Scioltamente (*Music*). Freely; the expression is synonymous with *ad libitum* (*q.v.*).

Sclerenchyma (*Botany*). The term applied to thick walled, lignified cells met with in plants. The function of the tissue is to give support.

Sconce (*Furniture, etc.*) (1) A bracket fixed to and projecting from a wall, and intended to hold a light, generally a candle or candles. (2) The receptacle for holding the candle in an ordinary candlestick; the term is also applied to the brim which surrounds the receptacle.

Scoop Wheel (*Eng.*) A wheel resembling a water wheel, turned by power, and employed for raising water from a lower to a higher level; used occasionally in drainage and irrigation work.

Score (*Music*). Two or more staves braced together, so called from the bars being "scored" through the set of staves. Score is of five kinds: (1) full or orchestral; (2) vocal or open; (3) short or compressed; (4) pianoforte or organ score; (5) supplementary. (1) In a full score each part or set of parts of the orchestra (and voices, if any) are displayed on a separate stave. The various instruments are generally arranged in groups, *e.g.* the "Wood wind," the "Brass," the "Strings," the "Percussion"; but the order of the groups varies considerably in different scores. It will be impossible to give more than one arrangement here:

Wood wind
- Fl. Picc. (Piccolo)
- Flauti (Flutes)
- Oboi (Oboes)
- *Corno Inglese (Cor Anglais)
- Clarinetti in B (or A) (Clarionets)
- *Clar. Basso (Bass Clarionet)
- Fagotti (Bassoons)
- *Contra Fagotti (Double Bassoons)

Brass
- Corni 1, 2, in . . . } (Horns)
- Corni 3, 4, in . . . }
- Trombe in . . . (Trumpets)
- *Tromba Bassa (Bass Trumpet)
- Trombone 1 } or combined on one or two staves.
- Trombone 2 }
- Trombone 3 }
- *Tuba

Percussion
- Tympani in . . . (Kettle Drums)
- Piatti (Cymbals)
- Triangolo (Triangle)

- Arpa (Harp)

Strings (part of)
- Viol. 1 (1st Violins)
- Viol. 2 (2nd Violins)
- Viola

Voices
- Soprano
- Alto
- Tenor
- Bass

Strings (part of)
- Violoncello
- Basso (Double Bass)

- Organ

In military band scores the following instruments (or some of them) will be found, arranged somewhat in this order:

Piccolo in E♭,
Flute in E♭ (or together on one stave);
E♭ Clarionets·
Oboes;
1st B♭ Clarionets;
2nd B♭ Clarionets;
3rd and 4th B♭ Clarionets;
Tenor Clarionets in E♭;
Bass Clarionets;
Saxophones;
Bassoons;
1st Cornets;
2nd Cornets;
1st and 2nd Horns;
3rd and 4th Horns (or Saxhorns);
Baritones;
Trumpets;
Trombones;
Euphonium;
Bombardons (String Basses);
Side Drum;
Bass Drum;
Cymbals;
Triangle;
Carillon.

For examples of notation of all these instruments, see MUSICAL INSTRUMENTS (pp. 426–445) and TRANSPOSITION. (2) In vocal score each voice is written on a separate stave, with the proper clefs. The soprano clef, however, is seldom used now; in fact, the majority of modern music has the G clef for the soprano, alto, and tenor staves. In this case the tenor part is written an octave higher than it is sung. Modern vocal score therefore appears thus:

SOPRANO.

ALTO.

TENOR (*an 8va lower*).

BASS.

(3) Short score has the soprano and alto parts written on the treble stave, the soprano notes having the tails turned up, and the alto notes with the tails turned down, and the tenor and bass parts on the bass stave, the tenor notes having the tails turned up, and the bass notes with the tails turned down. Short or compressed score is also applied to orchestral works written on two staves only for performance on the organ or pianoforte, and very often having only the principal parts in full. (4) Pianoforte music is written on two staves, *viz.* the treble and bass braced together as in short score. Organ music is generally written on three staves, thus:

MANUALS.

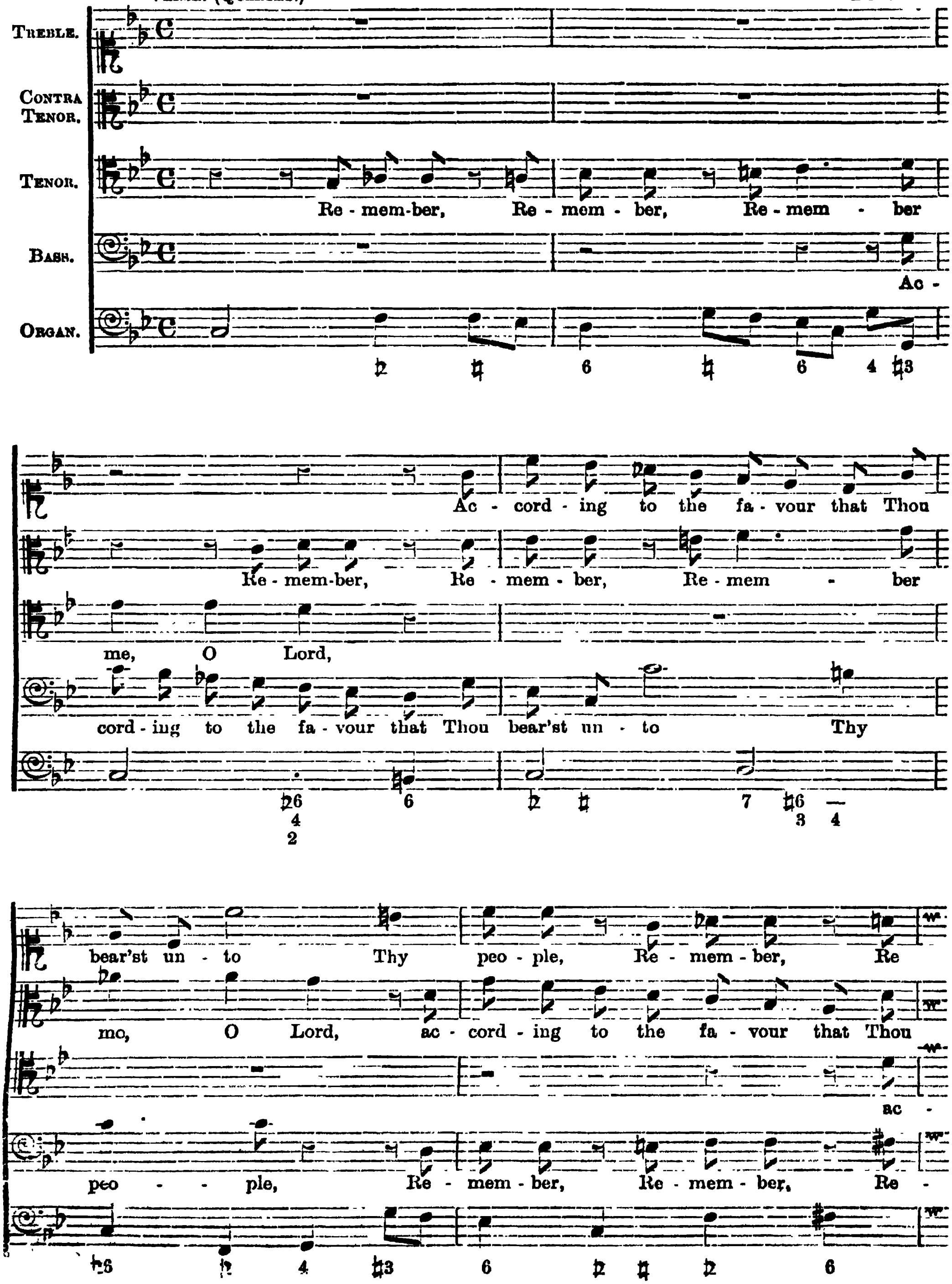
PEDALS.

In older music the organ, harpsichord, or pianoforte part of a vocal composition was printed on a single stave with the figuring of the chords. This was known as figured bass. The following examples show the beginning of the quartet from Purcell's anthem, "O give thanks," firstly, in vocal score with the figured bass organ part; and secondly, in short score with the organ part, as it should be played.

* These instruments are less frequently met with.

EXAMPLE OF VOCAL SCORE WITH FIGURED BASS.

VERSE. (QUARTET.) PURCELL.



EXAMPLE OF SHORT SCORE WITH ORGAN ACCOMPANIMENT.

(5) Supplementary score is an arrangement for certain instruments, such as the "percussion" or trombones, placed at the end of the full score, when owing to lack of space it is found impossible or difficult to print them on the one page. *See also* CLEF, STAVE, *and* TRANSPOSING INSTRUMENTS.

Scoria (*Geol.*) A general name for the larger fragments of vesicular lava ejected from a volcano during explosive eruptions. But an eruptive rock is said to be scoriaceous if it happens to be full of vapour cavities so as to resemble a sponge.

—— (*Met., etc.*) (1) Slag of a cindery character. (2) The recrement of fused metals.

Scorification (*Met.*) The addition of lead to copper which is required for rolling into sheets; the term refers to the production of scoriæ, which occurs on the surface of the fluid metal.

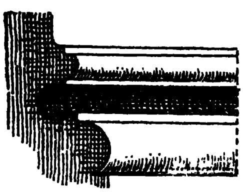
Scotch Dressing (*Cotton Manufac.*) *See* DRESSING.

Scotch Pig Iron (*Met.*) Iron from the Clyde districts, chiefly made from black band or clay ironstone; it is much used for ordinary foundry work.

Scotch Snap (*Music*). The peculiarity of a short note preceding a long one in Scotch melodies, especially the strathspeys.

Scotch Tuyere (*Met.*) A TUYERE (*q.v.*) cooled by water circulating in a pipe coiled round the tuyere.

Scotia (*Architect.*) A hollow moulding frequently used in the bases of columns in Greek, Roman, and Renaissance architecture. It separates the two torii in the Attic base. It is also known as a Trochilus, and a similar moulding used in Gothic architecture is known as a Casement or Casemate. *See* ATTIC BASE *and* CASEMATE.



SCOTIA.

Scouring. Cleaning by rubbing with sand and water or dilute acid; used in tin plate manufacture.

—— (*Leather Manufac.*) The scouring or cleaning of leather after the rough tanning has been done, and previous to polishing and finishing. Scouring may be effected by hand or machine, with brush, stone, brass, or steel tools, or by rotating the leather in a drum with sumach.

—— (*Woollen or Worsted Manufac.*) This term relates to the washing of wool, yarn, and cloth, the machines for each being entirely different in construction.

Scraper (*Bind.*) A steel implement used for scraping the edges of books in order to secure an even surface before gilding or burnishing.

—— (*Eng.*) The tool used in SCRAPING and SURFACING metal (*q.v.*) It usually consists of an old file ground to a sharp edge of convenient shape.

—— (*Joinery, etc.*) A flat blade of steel used in smoothing a wooden surface. The edge is usually ground and set at a right angle, and a smooth piece of steel is drawn along it in order to produce a wire edge or burr, which serves as the actual cutting edge.

Scraping (*Eng.*) The final process of preparing an accurately plane surface where a very good fit is essential: totally distinct from scraping woodwork, which aims at a good appearance only. The irregularities of the surface are found by rubbing a film of red lead and oil on a SURFACE PLATE (*q.v.*) or on an already finished surface which has to make a fit with the one being operated on. On placing the two surfaces in contact, patches of red lead appear on the projecting portions, and these are cautiously removed by the scraper, and the test is repeated. The process is slow and laborious, but the results which can be obtained in this way are marvellously accurate, and cannot be approached by any other method in engineering work.

—— (*Joinery, etc.*) Smoothing the surface work with the SCRAPER (*q.v.*) preparatory to final finishing, varnishing, etc.

Scrap Iron *or* **Scrap** (*Eng.*) Old iron, whether cast or wrought. The former is re-melted along with fresh pig iron for foundry use, and the latter can be re-welded if of sufficiently good quality.

Scrap Steel (*Met.*) Scrap steel is added to the charge in certain processes for the production of steel, *e.g.* the Open Hearth and Siemens Processes (*q.v.*)

Scratched Figures (*Typog.*) Figures with a line drawn diagonally across the face, as $\cancel{1}$, $\cancel{2}$, $\cancel{3}$: used in mathematical works.

Scree (*Geol.*) *See* SCREES.

Screed (*Plastering*). (1) A narrow line of plaster laid to the desired thickness, and when hard used as a guide for the floating rule. (2) A narrow ground of wood fixed as a guide for plastering.

Screen (*Carp. and Join.*) Framing, either panelled or having the upper part glazed; used as a partition.

—— (*Lantern Work*). A flat white surface, either opaque or transparent, according as the lantern is placed in front of or behind the screen. The former method is much the better. In this case the best screen is a surface coated with dead white plaster; a whitewashed wall is perhaps next best; then a good paper faced screen. The common linen screen is far too transparent, but owes its popularity to its portability.

——, **Electric.** A closed conductor within which a piece of apparatus (*e.g.* an electroscope) can be placed in order to protect it from external electrical influences. A fairly effective screen may be formed by metal gauze or even by a wire cage.

——, **Magnetic.** A closed or nearly closed case or cover of thick iron for protecting magnetic apparatus from external magnetic influences. The shielding effect is never as complete as in the corresponding case of an electric screen.

——, **Methuen's.** *See* METHUEN SCREEN.

——, **Photozincographic.** *See* PROCESS WORK.

Screes (*Geol.*) A term originating in the north of England, but now used elsewhere, and applied to the long trains of rock fragments which strew the slopes of a hill below a crag, and which are due to the weathering of the rock which forms the crag. In most cases they represent the amount of disintegration of the parent rock since the close of the Age of Snow.

Screw. If a helical groove be cut on a cylindrical (or conical) object a SCREW is produced. The portion of the original material which remains between the parts cut away in forming the groove is termed the THREAD of the screw. The distance between

consecutive turns of the thread is termed the PITCH of the screw. The DEPTH OF THE THREAD is the depth of the groove; the FORM OF THE THREAD is the shape of its cross-section when cut by a plane passing through the axis of the screw: if the groove be rectangular in form, a SQUARE THREAD is produced. *See also* SCREW THREADS. The cutting of the groove which forms the thread produces a new surface of peculiar character, which forms the sides of the thread; this is known as a SCREW SURFACE, and may be considered (mathematically) to be produced as follows: Let a fixed straight line be taken to represent the AXIS of the screw, and let another line, termed the GENERATING LINE, intersect it at a constant angle. Then if the generating line rotate uniformly about the axis, and at the same time the point of intersection move uniformly along the axis, the surface generated by the motion will be a Screw Surface. The pitch of the screw surface will be the distance which the point of intersection moves along the axis during one revolution of the generating line. If two (or more) grooves be cut round the same cylinder, parallel to each other, a TWO-THREADED (or MULTIPLE-THREADED) SCREW is produced. A screw usually turns in a NUT, an object having a cylindrical hole provided with a replica of the screw thread, into which the screw fits smoothly. A single turn of the screw relative to the nut causes a relative longitudinal movement between the two, equal in amount to the pitch of the screw. Screws in practice are usually of metal, wood being employed in a few instances only, *e.g.* for carpenters' bench vices, wood clamps, etc. Metal screws are cut by stocks and dies, screw cutting lathes, screwing machines, etc. (*q.v.*) The nut is formed by taps (*q.v.*) or by a lathe or machine. The process of cutting screws by the use of a chaser (*q.v.*) was once common, but is now almost obsolete, except in some kinds of light work, *e.g.* the formation of a thread on a thin tube, such as is used in some optical instruments. The uses of screws are readily classified under two heads: (1) As a means of fastening (*e.g.* wood screws, bolts and nuts, etc.); (2) as a means of producing regular linear motion (*e.g.* the leading screw of a screw cutting lathe, in a screw jack, screw gauge, etc.)

Screw Barrel (*Eng.*) A cylindrical roller or drum having a helical groove (*see* SCREW) cut in its surface for the reception of a chain which is wound up on the drum.

Screw Blade (*Eng.*) The blade of a SCREW PROPELLER (*q.v.*)

Screw Bolt (*Eng., etc.*) An ordinary BOLT (*q.v.*)

Screw Chase (*Typog.*) Screw chases are used chiefly for newspaper work. The type is secured by the action of set screws instead of quoins.

Screw Chasing (*Eng.*) Cutting screws by hand with a CHASING TOOL, a flat bladed tool having teeth corresponding to the form of the thread. This tool is moved along the top of the rest as the work rotates in the lathe. By properly judging the rate of motion a screw thread can be cut with fair accuracy.

Screw Clamp (*Join., etc.*) A device for holding the parts of a piece of work in place or for forcing them into position. The requisite pressure is applied by means of a screw. The tool may be made of either wood or metal.

Screw Composing Stick (*Typog.*) A form of composing stick in which the slide is secured by means of a screw and slotted nut instead of by a spring. *See* TYPOGRAPHY.

Screw Cutting (*Eng.*) This term is usually applied to the cutting of screws in the SCREW CUTTING LATHE (*q.v.*) Screws are also cut by CHASING, by STOCKS AND DIES, and by SCREWING MACHINES (*q.v.*)

Screw Cutting Lathe (*Eng.*) A lathe in which the slide rest carrying the cutting tool is made to travel along the bed with a uniform velocity, which is duly proportioned to the rate of rotation of the work in the lathe. This "travel" is obtained by the LEADING SCREW, a square threaded screw actuating a nut fixed to the slide rest. The rate of rotation of the screw is governed by a train of CHANGE WHEELS, connecting the leading screw to the mandrel of the lathe. The wheels are so chosen that the tool travels through a distance equal to the PITCH of the screw (*see* SCREW), while the mandrel makes one revolution.

Screw Dies (*Eng.*) *See* STOCKS AND DIES.

Screw Driver. The tool used for driving in or drawing out screws which are provided with a slotted head, whether in wood or metal work. The blade is often made broad, in order to give stiffness; but a circular section, of diameter not exceeding that of the screw head, is preferable. The handle should be broad, to afford effective leverage.

Screw Driver Bit (*Carp., Eng., etc.*) A screw driver blade made to fit a BRACE (*q.v.*)

Screw Feed (*Eng., etc.*) Mechanism in which the feed of a cutting tool, or slow motion of any other part, is obtained by a screw and nut.

Screw Gauge. An instrument for measuring the length or diameter of small objects with accuracy. A well cut screw, whose pitch is exactly known, turns in a nut fixed to the frame of the instrument; a stop is attached to the latter in line with the axis of the screw, so that by rotating the screw, a gap or opening of any desired width (up to the limit allowed by the dimensions of the instrument) may be formed. The object to be measured is placed in this gap, and the screw adjusted till the object fits exactly, without shake, between the stop and the end of the screw. The exact distance between the two latter may be read off on a scale engraved on the apparatus.

Screw Gearing (*Eng.*) (1) Worm gearing (*q.v.*) (2) Gear wheels whose teeth are not at right angles to the plane of the wheel. The teeth in this case may form portions of screw threads; such gearing is useful for connecting two shafts making an angle with each other.

Screw Head. The top part of a screw, by means of which it is turned. It may be either SLOTTED, as in wood screws, or SQUARE, HEXAGONAL, etc., to fit a spanner or key, or MILLED (*q.v.*) to enable it to be turned by hand.

Screwing (*Eng., etc.*) (1) The cutting of screw threads. Applied especially to cutting threads by means of dies worked either by hand or by a SCREWING MACHINE (*q.v.*) (2) Turning a screw or nut in order to cause it to advance or recede.

Screwing Machine (*Eng.*) A machine usually resembling a lathe in form, by means of which a succession of similar screw threads can be rapidly cut on the ends of bolts, rods, etc. The rod may pass through a hollow mandrel, and the dies be fixed; or the dies may rotate in jaws fixed on the mandrel,

and the work be held in a slide rest. The former method is adopted when a number of similar screws are being made from one length of rod. Various tools for cutting and finishing the screw, as well as the screwing dies, are fixed in a TURRET (*q.v.*), and can be caused to act on the work in succession. In some machines the whole of the operations are made automatic, when one workman can attend to a number of machines.

Screwing Tackle (*Eng.*) STOCKS AND DIES, TAPS, etc. (*q.v.*), used in producing screws by hand.

Screw Jack (*Eng.*) A portable device for raising heavy weights through a small distance. It consists essentially of a vertical screw working in a nut supported on a suitable frame or body. The screw is turned by force applied at the end of a lever handle or bar, which is put through a hole in the head of the screw; the screw rises slowly, exerting very great lifting force.

Screw Key (*Eng., etc.*) A SPANNER (*q.v.*)

Screw Mandrel (*Eng.*) A TRAVERSING MANDREL (*q.v.*)

Screw Micrometer. A piece of apparatus for the accurate measurement of small distances, based on the motion of a screw. A SCREW GAUGE is a form of screw micrometer.

Screw Nail (*Carp.*) An old and somewhat misleading term for a WOOD SCREW. *See* SCREW.

Screw Pile (*Civil Eng.*) A PILE (*q.v.*) with a screw at the lower end. It is driven into the ground by rotation instead of by blows from a falling weight. *See* SCREW.

Screw Plate (*Eng., etc.*) A hard steel plate forming a number of dies for cutting small screws. Screwed holes are made in the plate, and very often slots are cut in opposite sides of the hole, so as to form cutting edges. Screw plates are inferior to STOCKS AND DIES (*q.v.*), which are used for larger work.

Screw Press. A device for exerting pressure by means of a powerful screw, which acts on the object to be compressed.

Screw Propeller (*Eng.*) Often termed a Screw or a Propeller. It consists of a central HUB or BOSS, mounted on the propeller or screw shaft which projects from the stern of the vessel. From this boss project two (or more) BLADES, which form parts of two modified screw surfaces. *See* SCREW. The propeller is usually made of Manganese Bronze (*q.v.*), and may either be cast in one piece, or the blades may be attached separately to the boss. Two screws are often used in modern vessels, one being placed on each side of the keel post; this arrangement, termed TWIN SCREWS, necessitates, of course, the fitting of two engines and propeller shafts, which are completely independent of each other.

Screw Shaft *or* **Propeller Shaft** (*Eng.*) The steel shaft which communicates the motion of the engines to the propeller of a steamship. It is carried on bearings rigidly fixed to the lower part of the framing of the vessel. The longitudinal force on the shaft is balanced by a THRUST BLOCK (*q.v.*) The shaft and its bearings run in a tunnel, along which a man can pass in order to examine and lubricate the bearings.

Screw Stock (*Eng.*) *See* STOCKS AND DIES.

Screw Surface. *See* SCREW.

Screw Tap (*Eng.*) A TAP (*q.v.*) for cutting an internal thread.

Screw Threads (*Eng., etc.*) The threads of screws vary in two particulars—form or shape, and pitch. The form of a thread is the shape of its cross section; this is usually square, rounded, or angular. The top and bottom of an angular thread are rounded in the case of the usual English type, known as the WHITWORTH THREAD; in the American STANDARD THREAD they are flattened. These two forms of thread are shown in the figures. Fig. 1 shows the section of the Whitworth Thread; the angle is 55°, and the top and bottom are rounded

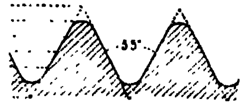


FIG. 1

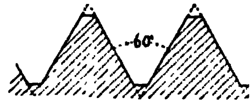


FIG. 2.

off to one-sixth of the depth. Fig. 2 shows the American Standard Thread, the angle being 60°, and the top and bottom being flattened. The width of the flat in each case is one-eighth of the pitch of the screw. The pitches of the principal threads are as follows:

(1) WHITWORTH THREADS.

Diameter in inches.	No. of threads per inch.	Diameter in inches.	No. of threads per inch.
$\frac{1}{4}$	20	1	8
$\frac{3}{8}$	16	$1\frac{1}{4}$	7
$\frac{1}{2}$	12	$1\frac{1}{2}$	6
$\frac{5}{8}$	11	$1\frac{3}{4}$	5
$\frac{3}{4}$	10	2	$4\frac{1}{2}$
$\frac{7}{8}$	9		

(2) GAS THREADS.

Diameter in inches	No. of threads per inch.
$\frac{1}{8}$	28
$\frac{1}{4}$ and $\frac{3}{8}$	19
$\frac{1}{2}$ and $\frac{3}{4}$	14
1 and upwards	11

(3) AMERICAN STANDARD THREAD.—The pitch follows very closely the Whitworth Thread given above.

(4) BRITISH ASSOCIATION or B. A. THREADS.—A standard for small screws used in electrical and other scientific work. The different sizes are numbered as follows:

Number.	Diameter in millimetres.	Pitch in millimetres.
0	6·0	1·0
1	5·3	·9
2	4·7	·81
3	4·1	·73
4	3·64	·66
5	3·2	·59
6	2·8	·53
7	2·5	·48
8	2·2	·43
9	1·9	·39
10	1·7	

(5) INTERNATIONAL STANDARD THREAD.—This is

also a millimetre thread, recommended by an International Congress in 1898:

Diameter in millimetres.	Pitch in millimetres.
6 and 7	1·0
8 and 9	1·25
10 and 11	1·5
12	1·75
14 and 16	2·0
18 to 22	2·5
24 to 27	3·0
30 to 33	3·5
36 to 39	4·0
42 to 45	4·5

Screw Tool (*Eng.*) A slide rest tool whose end is formed to correspond to the groove cut in forming a screw thread; it may be square, V-shaped, etc.

Screw Wrench (*Eng.*) A SPANNER (*q.v.*) with jaws whose distance apart can be adjusted by means of a screw, to fit different sized nuts.

Scribe, Scriber, *or* **Scribing Iron** (*Eng.*) A tool having a sharp point or edge, used for marking lines on metal or wood.

Scribed Joint (*Carp. and Join.*) *See* SCRIBING.

Scribing (*Eng., Carp., etc.*) (1) Marking lines on metal, wood, etc., preparatory to cutting the material to any required form. (2) Cutting the end of a piece of moulding to the profile of another piece, so that the two may fit closely together: *e.g.* the bars of a window sash are generally scribed at their ends, where they meet another bar or the frame of the sash. The mouldings thus intersect each other exactly: but there is no weakening of one member such as would be produced if the joint were mitred.

Scribing Block (*Eng.*) A support carrying a scribe, which can be fixed in various positions. The base of the support or block is usually an accurately plane surface which is laid on a SURFACE PLATE (*q.v.*) If the block be moved about on the surface plate, the point of the scribe moves parallel to the plate; hence lines can be marked on a piece of work, so as to be accurately parallel to a face of the work which rests on the surface plate.

Scribing Gouge (*Carp. and Join.*) A gouge which has the bevelled edge on the concave side; a PARING GOUGE. Used by joiners in making a scribed joint.

Scrim (*Dec.*) Thin canvas used for covering battened walls before papering.

Scrinium (*Archæol.*) A case, generally cylindrical in form, used in early times for holding writings, etc., *e.g.* parchment rolls.

Scrip (*Archæol.*) A wallet or pouch such as was carried by pilgrims. Used in Heraldry as a charge, often in conjunction with a pilgrim's staff.

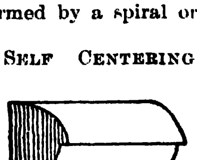
Script (*Typog.*) The name of a style of type imitating writing.

Scroll (*Carp. and Join.*) The ornamental curved end of a handrail.

—— (*Dec.*) An ornament formed by a spiral or involute curve.

Scroll Chuck (*Eng.*) A SELF CENTERING CHUCK (*q.v.*)

Scroll Moulding (*Architect.*) A Gothic moulding characteristic of the Decorated period and consisting of two half rounds, the upper one projecting slightly beyond the lower. *See also* ROLL MOULDING.



Scroll Opener (*Textile Manufac.*) The appliance used for keeping the cloth fully stretched in the process of scouring. It consists of a pair of scroll rollers and a tensioning frame for keeping the cloth in the centre of the main rollers of the scouring machine.

Scrubbers (*Gas Manufac.*) *See* GAS MANUFACTURE.

Scrutoir (*Furniture*). A writing desk with a hinged flap or door which, when open, forms a table for writing upon; an escritoire.

Scudding (*Leather Manufac.*) Removal of the SCUD, a term applied to the impurities, such as fat glands, hair roots, pigment cells, lime salts, etc. This is done in the wet state by working the skins over a beam with a blunt knife or a slate while in the limed or "pucred" state.

Sculls (*Met., etc.*) Skins of metal, slag, scale, etc., which form on the inside of foundry ladles, and remain after the fluid metal is poured out.

Sculpsit (*Engrav., etc.*) This Latin word, placed after the name of an individual on an engraving or on a piece of statuary, indicates the engraver and the sculptor respectively. Abbreviation, *sculp.* or *sculps.*

Sculptor's Varnish. *See* VARNISHES.

Sculpture, Schools of. The history of sculpture can be carried back much farther than that of painting, because the permanency of the materials used by sculptors has made possible the preservation of many works executed in very remote ages. It begins really with the scratched and chipped bones which represent the tentative efforts of prehistoric man, but its continuous record starts more than thirty centuries before the Christian era in that cradle of the arts, Egypt. The earliest known EGYPTIAN SCULPTURES suggest by the accuracy of their convention, and the technical skill that they reveal, a long preparatory period of which no traces now remain. The greater merits of the existing examples are the true understanding of individual character which distinguishes the works from nature, and the dignified sense of design which even the formalities of the style chosen do not entirely disguise. Contemporaneous with the later Egyptian school was that of ASSYRIA, which produced the great winged bulls, the exquisite bas-reliefs of hunting scenes and other incidents in the life of the period, and the representations of kings and dignitaries, which are all justly reckoned among the most memorable instances of the art of sculpture that the world has seen. We have in the British Museum several of the best of these carvings, and there are others of much importance in the Louvre. The next development was that of the GREEK SCHOOL. This began in a primitive fashion as early as 1000 B.C., and its archaic stage lasted for nearly five hundred years. Then came a brief transitional period, which was followed immediately by what is known as the Great Age of Greek sculpture. The chief artist of the transition was Myron, a copy of whose "Throwing Discobolus" is to be seen at Rome with other copies of his works. The first, and perhaps the greatest, of the sculptors of the Great Age was Phidias, a younger contemporary of Myron. He is thought to have been born about 480 B.C., and is known to have completed his great gold and ivory statue of Athene for the Parthenon in 438. The exquisite sculptures from

the Parthenon, which are preserved in the British Museum, are also thought to have been inspired and supervised by Phidias; some of them may have been actually executed by him, but the bulk were probably carried out by his pupils. Among the contemporaries of Phidias were Polyclitus of Argos, copies of whose works exist at Naples and Berlin. Early in the fourth century B.C. flourished Scopas, and Praxiteles, one of the greatest of the Greek sculptors, who executed the often mentioned "Aphrodite of Cnidus," the superb "Hermes" at Olympia, and probably the "Leaning Satyr" at Rome. To Scopas is assigned, but on questionable authority, the group of "Niobe and her Children," of which copies are preserved at Florence. The last sculptor of the Great Age was Lysippus of Sicyon, who is supposed to have been the author of the "Apoxyomenos" in the Vatican. Then succeeded a period of less distinction, during which both the taste and the power of the Greek sculptors degenerated. To the commencement of it belong two of the chief treasures of the Louvre, the "Victory of Samothrace" and the "Aphrodite of Melos"; but as it went on, affectations and a desire for sensation—illustrated in such works as the "Apollo Belvedere" and the "Laocoön"—crept in and destroyed the purity of the classic style. Among the ROMANS the art of sculpture had no real vitality. Hardly any original works were produced, and the sculptors, who were usually Greeks and often slaves, occupied themselves chiefly with imitations or copies of the earlier Greek masterpieces. The early Christians, too, though they to some extent encouraged painting, disregarded sculpture almost entirely. The first steps towards the foundation of a new school were taken early in the thirteenth century of the Christian era, when Nicola Pisano created a tradition which, though it was akin to the antique in its respect for beauty, was essentially inspired by the spirit of the times. This tradition was carried further by his son Giovanni, and after him it was developed by a succession of great craftsmen into a guiding principle which determined the whole direction of ITALIAN SCULPTURE. Towards the end of the fourteenth century appeared Ghiberti, who executed the great gates of the Baptistery at Florence, and Donatello, a sculptor of exquisite skill and refinement. Then came Luca Della Robbia, born in 1400, the head of a family which became famous by the beauty of the work which they accomplished in coloured and glazed terracotta; and lastly came, in 1474, Michael Angelo Buonarroti, the greatest of all the Italian sculptors, and the man in whom the movement which had been in progress for more than two centuries finally culminated. He may fairly be called the Phidias of the Renaissance; but, unlike the Greek master, he had no successors of anything like the same rank. In 1504 he finished his colossal statue of David at Florence, and in the following year he commenced the monument of Julius II., which was never finished. In 1524 he began the Medici tombs for the sacristy of San Lorenzo at Florence, which were completed nearly ten years later. These are perhaps his greatest works. While Michael Angelo was working there was growing up in France a school of much importance. The first man of note in it was Michel Columbe, who was born about 1430; but he was surpassed by his sixteenth century successors, Jean Goujon and Germain Pilon, the former of whom executed the "Diane Chasseresse," now in the Louvre, and the latter the group of the "Three Graces." With them began a long list of able sculptors, which includes many famous names—for instance, C. M. Clodion (1738—1814), J. A. Houdon (1741—1828), J. Pradier (1792—1862), P. J. David (1789—1856), F. Rude (1784—1855), and A. L. Barye (1796—1875); and moderns like J. B. Carpeaux, E. Frémiet, A. N. Cain, H. M. Chapu, J. A. Falguière, A. Mercié, Jules Dalou, and Auguste Rodin. By the efforts of artists such as these the French school of sculpture has been given in the history of the art a place of very great distinction. In ENGLAND the native school may be said to have begun with John Flaxman (1755—1826), a contemporary of the Italian Canova (1757—1822), and the Dane Thorwaldsen (1770—1844), and, like them, a follower of the classic tradition. After him came Chantrey (1782—1841), Westmacott (1775—1856), John Gibson (1780—1866), and M. C. Wyatt (1778—1862), and others of considerable ability. The greatest development of English sculpture has come, however, during recent years. It promises to attain in the future a position of much more prominence than it has reached in the past. In GERMANY also and BELGIUM there are recent schools, which are growing in importance; and there are some sculptors of ability in Russia and America.—A. L. B.

Scumbling (*Art*). (1) Softening the colours of an oil painting by blending with a neutral tint which is applied comparatively dry by means of a brush or the finger. (2) Softening the outlines of a drawing by rubbing with the stump or the blunt end of the chalk.

Scum Cock (*Eng.*) A tap or cock in a boiler used for drawing off the floating scum from the surface of the water.

Scutcheon (*Her.*) *See* ESCUTCHEON.

Scutching (*Cotton Manufac.*) A further process of opening (*q.v.*) and cleaning. The cotton in this case is fed in a uniformly rolled lap form, three or four being run together. *See also* COTTON MANUFACTURE.

—— (*Linen Manufac.*) After the flax has been steeped or retted and grassed, the bone or woody portion of the stem is cleared away from the fibre. The process, called scutching, consists of placing the flax in handfuls over an upright slab, and beating the ends of it with a blade till all the bone is cleared away. This is usually done in mills by means of revolving blades driven by water power.

Scutum (*Arm.*) A large oblong shield used by the Romans. It was constructed of some light material, covered with hide, and curved so as to fit close to the body.

Sdegno, Con (*Music*). With scorn.

Se (*Chem.*) The symbol for SELENIUM (*q.v.*)

Sea Beach (*Geol.*) Strictly speaking, a sea beach is a deposit of sand and shingle piled upon the shore platform by the action of the waves; but the term is often applied to the rock-shelf gradually hewn between tide marks by the prolonged mechanical action of the waves.

Sea Breeze (*Meteorol.*) *See* LAND AND SEA BREEZES.

Sea Cock (*Eng.*) A tap or cock in a tube leading from the sea water into the condenser of a marine engine.

Sea, Erosion by (*Geol.*) The mechanical erosion effected by the sea usually takes place between tide marks, and in the majority of cases this action mainly consists in the gradual reduction in size and the ultimate removal of rock material detached by

weathering from the cliffs above high water mark. But a certain amount of erosion is directly effected by the waves, especially on coasts liable to heavy seas. Most of this is accomplished at a very slow rate if the rocks affected are of a durable kind; and the wasting is carried out chiefly by the gradual enlargement of chinks, joints, fissures of any kind, or any zones of weakness in the rocks lying within reach of the waves. These weak places are gradually widened, the rocks are tunnelled into sea caverns, their roofs in time are blown off during some exceptionally violent gale, the sides of the whilom caverns in time are worn into sea stacks, these into skerries (only visible at low tide), and these skerries eventually into a shore platform, which is levelled off to the same elevation for great distances along the coast line. Chemical action also takes an important share in the work. For example, a basalt, containing, as it does, a ferromagnesian silicate and a lime soda felspar, will decompose on the land in such a manner that the felspar goes first and the ferromagnesian silicate last; but where the same rock is exposed to the chemical action of sea water the order of decomposition is reversed and the felspar may remain apparently unchanged after the rest of the rock has disappeared. It is now believed, with good reason, that the more energetic (but irregular) action of marine erosion is less effective in the long run than the quieter (but continuous) action of subaërial denudation.

Seal. (1) A piece of metal or stone (sometimes a gem) with a design or device engraved upon it; used for making an impression on some suitable substance such as wax. (2) The impression so obtained. *Cf.* SCARAB.

—— (*Eng.*) The slight projection of the edge of a steam valve over the edge of a part which it covers. This makes a steam-tight joint.

—— (*Plumb.*) The fluid which fills the trap or bend of a drainage pipe and so prevents the upward passage of gases; also termed a WATER SEAL. Water can flow downwards, but gases cannot rise past the bend unless the pressure exceed a certain value. *See* SIPHON TRAP.

Sealing. In general, closing up, making a joint, or securing by the attachment of some substance which must be broken before the sealed joint can be opened. Glass apparatus is sealed by fusing together the edges of an opening or tube. A meter or registering apparatus is "sealed" by the attachment of a leaden seal, impressed with some device, to any convenient place, in such a manner that access to the interior cannot be obtained without breaking the seal or cutting wires which pass through it.

Seam (*Eng.*) A long joint between two plates or in a pipe made by bending a plate. The term is usually (but not always) restricted to welded or brazed joints, as distinguished from those which are riveted.

—— (*Mining*). A bed or layer of coal; occasionally the term is applied to a stratum of some other rock.

Seamless Tubes. SOLID DRAWN TUBES (*q.v.*)

Seam Set (*Eng.*) The tool used for closing up the seams in a tube formed from sheet metal.

Searchlight. A powerful arc lamp, provided with optical means whereby its rays can be concentrated in a narrow beam, and with mechanical devices for directing this beam in any required direction.

Searing (*Pattern Making*). Smoothing the surface of a roughly made pattern by means of a hot iron; this process also serves to render the surface less liable to absorb moisture from the sand.

Sea Sand (*Foundry*). This is suitable for making cores (*q.v.*), but requires the admixture of a small amount of clay in order to make it bind or adhere.

Seascape (*Art*). A picture representing a marine view.

Seasoning (*Leather Manufac.*) In the tanyard this means bringing the leather to a proper state of moisture (damping or drying) previous to rolling. In the dyeing and finishing of light leather, skins, after dyeing and before glazing, are coated with a seasoning liquid, consisting in most cases of albumen in some form, either vegetable or animal, mixed with various dilutants.

—— (*Timber*). Drying out the sap from timber before use; it is effected either naturally by exposure to the air, or by means of hot air (artificial seasoning). In the latter method a great part of the sap may be removed by soaking the timber in water previous to the artificial drying.

Seasons (*Astron.*) The divisions of the year, determined by the position of the earth in regard to the sun. The earth in its orbital motion round the sun keeps its axis nearly parallel to itself; the poles of the earth vary in their presentation to the sun, hence the different conditions of spring, summer, autumn, and winter.

Seat *or* **Seating** (*Eng.*) (1) A base plate in general. (2) The structure on which the movable part of a valve rests.

Seat Earth (*Geol.*) Another name for FIRECLAY.

Seat Lug (*Cycles*). The lug (*see* CYCLES) through which the seat pillar passes.

Sea Wall (*Civil Eng.*) An upright or, more commonly, sloping wall of masonry, concrete, etc., intended to protect the land from erosion or inundation.

Sea Water. Sea water contains about 3·5 per cent. of dissolved salts, of which about 2·7 per cent. consists of common salt. A fairly typical analysis of sea water gives:

Sodium chloride . . .	2·64 per cent.
Potassium chloride . . .	·07 " "
Magnesium chloride . .	·31 " "
Magnesium sulphate . .	·21 " "
Calcium sulphate . . .	·13 " "

In addition to these substances, there may be small amounts of iodine and of various other mineral salts. The specific gravity is usually between 1·024 and 1·027. Sea water is used in marine boilers, due precautions being taken to prevent too large an accumulation of salt.

Sec (*Music*). Sharp, crisp; often placed over certain notes.

——, **Secant.** *See* TRIGONOMETRICAL RATIOS.

Secco (*Music*). Plain, unadorned. *See* RECITATIVE.

Secohm (*Elect.*) The term formerly applied to the HENRY or unit of inductance.

Secohmmeter (*Elect.*) An apparatus for measuring self-induction and mutual induction.

Second. *See* WEIGHTS AND MEASURES.

Second (*Music*). The interval contained between two notes next to each other in alphabetical order, as C to D, C to D♯. *See* INTERVALS.

Secondaries to a Circle. *See* SPHERE.

Secondary Alcohol (*Chem.*) *See* ALCOHOL.

Secondary Alcohols (*Chem.*) Alcohols of the formula

$$\begin{matrix}R\\R_1\end{matrix}\!\!>C<\!\!\begin{matrix}H\\OH\end{matrix}$$

where R and R_1 are radicals joined by carbon to the carbon of the CHOH group, and may be the same or different. Examples:

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CHOH,\ \text{Isopropyl alcohol.}$$

$$\begin{matrix}CH_3\\C_2H_5\end{matrix}\!\!>CHOH,\ \begin{matrix}\text{Methylethyl carbinol.}\\\text{(2-Butanol)}\end{matrix}$$

The secondary alcohol group occurs in many important compounds; for example, in glycerine, $\begin{matrix}CH_2OH\\|\\CHOH\\|\\CH_2OH\end{matrix}$; in lactic acid, $\begin{matrix}CH_3\\|\\CHOH\\|\\COOH\end{matrix}$; in the sugars, in morphia, etc.

They may be prepared (1) from primary alcohols. *See* PROPYL ALCOHOLS. (2) By reduction of ketones. *See* KETONES. (3) From aldehydes by the action of zinc alkyls or magnesium alkyl iodides: *e.g.* with acetaldehyde and zinc methyl addition takes place—

$$\begin{matrix}CH_3\\|\\C\end{matrix}\!\!<\!\!\begin{matrix}O\\H\end{matrix} + Zn(CH_3)_2 = \begin{matrix}CH_3\\|\\C\end{matrix}\!\!<\!\!\begin{matrix}OZnCH_3\\CH_3\\H\end{matrix}$$

The compound so formed is decomposed by water —

$$\begin{matrix}CH_3\\|\\C\end{matrix}\!\!<\!\!\begin{matrix}OZnCH_3\\CH_3\\H\end{matrix} + HOH = \begin{matrix}CH_3\\|\\C\end{matrix}\!\!<\!\!\begin{matrix}OH\\CH_3\\H\end{matrix}$$
$$+ ZnO + CH_4.$$

(4) From formic esters by the zinc alkyls, using two molecular proportions of the latter. This is a particular case of method (3), for formic esters contain the aldehyde group—

$$\begin{matrix}H\\|\\C\\|\\OC_2H_5\end{matrix}\!\!<\!\!\begin{matrix}OZnCH_3\\CH_3\end{matrix} + Zn(CH_3)_2 = \begin{matrix}H\\|\\C\\|\\CH_3\end{matrix}\!\!<\!\!\begin{matrix}OZnCH_3\\CH_3\end{matrix} +$$
$$Zn\!<\!\!\begin{matrix}CH_3\\OC_2H_5\end{matrix}$$

The addition product is the same as in (3). The reactions of secondary alcohols with sodium, chlorides of phosphorus, acids, are in general like those of primary alcohols. On oxidisation they yield ketones (*q.v.*); thus isopropyl alcohol gives acetone and lactic acid gives pyruvic acid (*q.v.*) For a method of distinguishing secondary from primary and tertiary alcohols *see* NITROSO-COMPOUNDS.

Secondary Bases (*Chem.*) Compounds of the formula $\begin{matrix}R\\R_1\end{matrix}\!\!>NH$, where R and R_1 are radicals, which may be the same or different, attached to the nitrogen by carbon. For illustrations see the following compounds: DIETHYLAMINE, PIPERIDINE, CONINE.

Secondary Bows (*Meteorol.*) *See* RAINBOWS.

Secondary Cell *or* **Battery** (*Elect.*) *See* ACCUMULATORS.

Secondary Hydrocarbons (*Chem.*) A hydrocarbon containing at least one carbon atom united to three other carbon atoms, *e.g.* Isobutane—

$$CH_3CH<\!\!\begin{matrix}CH_3\\CH_3\end{matrix}$$

See PARAFFINS.

Secondary Rocks (*Geol.*) Usually understood to be the strata which in Europe were formed while Ammonites lived in the seas, and while the dominant forms of vertebrate life were reptiles of various kinds. The strata thus include all rocks of later date than the uppermost Carboniferous rocks on the one hand and the base of the oldest Eocene rocks on the other. *See* STRATA, TABLE OF.

Second Cut File (*Eng.*) A file with teeth next in order of coarseness to a SMOOTH CUT file (*q.v.*)

Secondo (*Music*). Second, as the second performer in a duet; the lower or bass part of a duet for one pianoforte. Seconda, 2ma or 2nd time, is often placed after a repeat to show that certain bars are to be substituted for those marked prima before the repeat. *See* PRIMO.

Second Tap (*Eng.*) *See* TAP.

Secret Dovetail (*Carp. and Join.*) A joint constructed so that the dovetails are hidden by a mitre. *See* DOVETAIL.

Secret Fixing (*Carp. and Join.*) The methods of fixing joinery so that the fixings cannot be seen.

Secret Nailing (*Carp. and Join.*) Nailing together the parts of a piece of work in such a way that the heads of the nails do not lie in the visible surface of the finished object. Thus flooring composed of narrow strips or blocks may be fixed down by nails driven obliquely through the edge (or vertical side) of one block, before the next block is laid in place.

Sectile (*Min.*) Capable of being cut by a knife, but not malleable; *e.g.* Steatite.

Section. (1) A cut across an object, the direction of the cut being stated, *e.g.* Cross, Horizontal, or Vertical Section. (2) A drawing of such a cut surface. (3) A distinct portion of a structure.

—— (*Typog. and Bind.*) (1) A distinct portion of a book: a sheet. *Cf.* SIGNATURE. (2) A subdivision of a chapter; hence the reference sign § used to denote such a division. *See* NOTES.

Sectional Area. The area of a section, especially of the cross section of an object.

Sectional Colours. Certain conventional colours are used in drawings to represent different materials, *e.g.* grey for cast iron, yellow for brass, etc.

Sectional Plan. A drawing showing the appearance which an object would present if it were cut through by a horizontal plane.

Sector. (1) The part of a circle lying between two radii and the portion of the circumference connecting them. The term is also applied to a similar

figure derived from other curves. (2) A form of divided scale used by draughtsmen. (3) An instrument for the measurement of angles. *See* ZENITH SECTOR.

Secular Changes (*Astron., Geol., etc.*) Changes which occur progressively throughout ages of time—*i.e.* in a vastly extended though indefinite period; *e.g.* movements of the earth's crust, or the gradual alterations in the value of the magnetic elements.

Sedan Chair. *See* CHAIR, SEDAN.

Sedilia (*Architect.*) The seats, usually three, which are frequently formed in the south wall of the chancel of churches and cathedrals. The singular of Sedilia, *Sedile*, is seldom used.

Sedimentary Rocks (*Geol.*) Strata deposited outside of the earth's crust directly or indirectly by the action of water, or of currents of air, or of ice. Rocks formed by volcanic action, properly so-called, are usually stratified, but they are excluded by the definition just given.

Seebeck Effect (*Elect.*) Thermo-electric phenomena (*q.v.*)

Seeding (*Chem. Tech.*) The separation of stearic and palmitic acids from liquid oleic acid by crystallisation in the manufacture of stearine. The fatty acids from the decomposed "rock" (*q.v.*) are run into shallow cooling pans arranged in stacks. The resultant slabs of granular solid acids and liquid oleic acid are known as SEPARATION CAKE.

Seggar (*Pot.*) A round, oval, or square box of burnt fireclay, varying in depth, in which clay wares are placed for the bisque oven, and bisque wares for the glost oven. In the latter case the seggars are glazed.

Seggar Clay (*Geol.*) Another name for FIRE-CLAY.

Segment. The part of a circle enclosed by an arc and a chord.

Segno (*Music*). The sign 𝄋. *See* AL SEGNO *and* DAL SEGNO.

Segregation Veins (*Geol.*) When an eruptive rock is cooling it necessarily contracts, and hence there is a tendency to the formation of fissures as the rock adapts itself to the space available. Some of the materials which consolidate later gradually ooze into these fissures, and eventually crystallise there. In an eruptive rock these segregation veins or Aplites, as they are now called, are always more acid in chemical composition than their enclosing rock.

Segue; Seguendo (*Music*). Follows: following. *Segue* is placed after one movement to indicate that the next follows on. *Attacca* is now used for the same purpose.

Seismograph. An instrument for recording (on a sheet of paper, smoked surface, etc.) the movements of the crust of the earth during an earthquake. The term is also applied to the traced or written record itself.

Seizing (*Eng.*) The fixing or jamming of a bearing which sometimes occurs when it becomes hot through insufficient lubrication.

Seizure (*Eng.*) Bearings, etc. *See* SEIZING.

Sekos (*Architect.*) The sanctuary in an ancient Egyptian temple.

Selenite (*Geol.*) A name applied to the clear varieties of GYPSUM (*q.v.*) Selenite occurs under geological conditions somewhat different from normal gypsum. It is quite commonly developed within clays, *e.g.* the London Clay or the Oxford Clay, probably as a result of the decomposition of pyrites and the recombination of the sulphuric acid thus formed with solution of carbonate of lime. But no selenite occurs in the chalk, though pyrites abounds in some parts of it.

Selenite (*Min.*) The transparent variety of GYPSUM (*q.v.*)

Selenium (*Chem.*) Se. Atomic weight, 79·2. (Also called Selenion.) A rare element closely resembling sulphur in its chemical behaviour, and belonging to the same group in the Periodic system. It is a solid having several allotropic forms. AMORPHOUS SELENIUM is a red powder obtained by reduction of selenious acid by sulphurous acid, stannous chloride, and other reducing agents; also by allowing a solution of selenium hydride to stand exposed to air. It is slightly soluble in carbon disulphide and benzene, and when allowed to stand under these solvents exposed to light it passes into the red crystalline form. Another amorphous form, known as vitreous selenium, is produced when melted selenium is rapidly cooled. CRYSTALLINE FORMS: A dark grey crystalline form with metallic lustre is obtained from either of the two preceding varieties by *gradually* heating them; at about 100° they pass into this form with evolution of heat, the temperature rising to 217°, which is the melting point of this variety. This variety is insoluble. The red crystalline form is obtained as above, and crystallises in two distinct forms—it changes on heating to the dark grey form. COLLOIDAL SELENIUM: Formed on reduction of very dilute solutions of selenious acid by sulphur dioxide or hydrazine hydrate; on dialysing the liquid a red solution showing blue fluorescence by reflected light is obtained; the solution may be boiled without change, but electrolytes precipitate red gelatinous selenium, which becomes black on heating. Selenium boils at 680°; below about 950° it contains complex molecules, probably Se_8; but at 950° and over the molecules consist of Se_2. In the vacuum of the kathode light it boils at 310° under the pressure of a 60 mm. column of its own vapour. Selenium is a bad conductor of electricity, but its resistance diminishes on exposure to light, the grey crystalline form being most sensitive; various physical applications have been made of this property. Selenium burns with a blue flame when heated in air forming the dioxide; in general its chemical behaviour resembles that of sulphur. Selenium occurs widely distributed, but always in small quantity; its two chief sources are the flue dust which is deposited in roasting sulphides such as selenium containing copper pyrites, and a deposit in the leaden chambers of the sulphuric acid manufacture when certain kinds of pyrites are burned. To obtain it from the latter, the deposit is washed and boiled with a concentrated solution of sodium sulphite. To the filtered liquid hydrochloric acid is added, which precipitates the selenium; the process is repeated till the selenium is pure. *Compounds:* Selenium hydride, H_2Se (Seleniuretted hydrogen) is a colourless gas; boils at −40°; smells like sulphuretted hydrogen at first, but has much more severe after-effects, irritating the mucous membrane and temporarily destroying the sense of smell; it is about as soluble in water as sulphuretted hydrogen, and like it gives precipitates with metals—selenides; decomposed by light. The gas is prepared

in a similar manner to sulphuretted hydrogen, namely, by heating the element in hydrogen; decomposing ferrous selenide with dilute hydrochloric acid; decomposing aluminium selenide with water. Selenious oxide, SeO_2, forms white needles, which sublime without melting, and dissolve in water, forming selenious acid. It is prepared by burning selenium in dry oxygen, or by the action of nitric acid on selenium, and repeated evaporation of the solution with water to obtain selenious acid, which gives the dioxide when heated in oxygen. Selenious acid, H_2SeO_3, crystallises in white prisms; when heated gives selenious oxide and water; soluble in water; the solution is easily reduced to the element (*see above*); oxidising agents convert it into selenic acid; forms both normal and acid selenites. The acid and its salts are poisons. Selenious acid is obtained as described under the oxide. Selenic acid, H_2SeO_4, crystallises in white prisms; melts at 58°; mixes with water with evolution of much heat; the solution behaves like sulphuric acid in most respects; the concentrated acid chars many organic substances when heated with them, while the dilute acid dissolves metals in an analogous manner to dilute sulphuric acid. Very concentrated selenic acid dissolves gold leaf, forming the dioxide and auric selenate, $Au_2(SeO_4)_3$. Heated with hydrochloric acid, selenious acid is formed with evolution of chlorine. The selenates resemble the sulphates except that they are decomposed by hydrochloric acid like selenic acid itself. Selenic acid is obtained by oxidising a solution of selenious acid with chlorine; or selenious acid is precipitated with silver nitrate, the precipitate washed, and oxidised with bromine and water; the solution of selenic acid is evaporated as far as possible on the water bath, then distilled in a vacuum till nothing more comes over at 180°. Selenium forms many organic compounds; special interest attaches to one of these, in which a selenium atom is united to four different monovalent groups, as it can be resolved into optically active components. Benzene sulphonic chloride and benzene react in presence of aluminium chloride to form diphenyl sulphone, which yields diphenyl diselenide when heated with sufficient selenium; the selenide yields methylphenylselenide with sodium and methyl iodide; this compound combines with bromacetic acid to form phenylmethylselenetine bromide—

$$C_6H_5SO_2Cl \xrightarrow[C_6H_6]{} (C_6H_5)_2SO_2 \xrightarrow[Se]{} C_6H_5Se.SeC_6H_5 \xrightarrow[CH_3I]{}$$

$$C_6H_5SeCH_3 \xrightarrow[CH_2BrCOOH]{} \begin{array}{c} CH_3 \\ C_6H_5 \end{array}\!\!>\!Se\!<\!\!\begin{array}{c} CH_2COOH \\ Br \end{array}$$

When this compound is precipitated with silver *d*-bromcamphorsulphonate, a product is obtained which can be separated by fractional crystallisation into dextro- and lævorotatory compounds.

Selenium (*Min.*) This element occurs native in cavities in the lavas of Vesuvius. It is of a dark brown or grey colour by reflected light, but red in thin pieces by transmitted light. The element also occurs in combination with sulphur and tellurium, and as selenide in several rare minerals. There is also one mineral which is a selenite, Chalcomenite.

Selenograph (*Astron.*) A picture of the surface of the moon, or some portion of it.

Selenography (*Astron.*) The study of the geography of the moon.

Self Acting Lathe (*Eng.*) This term is usually applied to a lathe in which both longitudinal and transverse motions can be given to the slide rest by means of a shaft fixed along the back of the bed. This longitudinal motion or feed is entirely independent of that used in screw cutting. The term "self acting" is, however, often applied to lathes which have the screw cutting mechanism only.

Self Centering Chuck (*Eng.*) A chuck with three (rarely two or four) jaws, which can be moved simultaneously in a radial direction across the face of the chuck, always remaining equidistant from the centre. A cylindrical object held in these jaws will always have its axis coincident with the axis of the chuck. The jaws are caused to move by some form of gearing, or by a spiral groove or scroll cut in a circular plate, each jaw having a projection which fits into the groove.

Self Delivery (*Foundry*). The formation of hollow parts of a casting without the use of cores, the actual hollow being formed on the pattern itself. The sand of the mould fills this hollow, and the necessity for a separately prepared core (*q.v.*) is obviated. Self delivery is only possible in a limited number of cases.

Self Exciting Dynamo (*Elect. Eng.*) A dynamo whose field magnets are excited by current produced by the machine itself, as distinguished from a SEPARATELY EXCITED MACHINE (*q.v.*)

Self Fluxing Ores (*Met.*) Applied to certain iron ores containing calcareous matter which serves as a FLUX (*q.v.*), so that the addition of lime to the furnace charge is not necessary.

Self Induction (*Elect.*) *See* INDUCTION, SELF.

Sellers' Screw Threads (*Eng.*) The American standard form of V-thread, having an angle of 60°; used in America instead of the Whitworth pattern. *See* SCREW THREADS.

Seltzer Water (*Chem.*) *See* WATER.

Selvedge *or* **Listing** (*Textile Manufac.*) The list or side threads of a fabric, usually composed of stronger threads than the main portion, so as to bear the increased friction and strain in the reed during the operation of weaving, and otherwise protect the real cloth. *See also* LIZIER.

Semaphore. A signal having a hinged lever arm, such as is used on railways and in the Navy. *See under* RAILWAYS.

Sémé *or* **Powdered** (*Her.*) A shield is described as *sémé* when covered with small charges scattered all over the surface. France ancient is *sémé* of *Fleur de lys*.

Semi-Beam *or* **Semi-Girder** (*Eng.*) A term sometimes applied to a CANTILEVER (*q.v.*)

Semibreve (*Music*). The name given to the standard note of measurement in modern music and to its equivalent rest. *See* NOTES *and* RESTS.

Semicarbazide (*Chem.*) $CO\!<\!\!\begin{array}{l} NH.NH_2 \\ NH_2 \end{array}$

(Aminourea). White prisms; melts at 96°; soluble in water, benzene, chloroform. Decomposes on keeping into hydrazine and hydrazodicarbonamide; it decomposes in the same way on heating.

$$2H_2N.NH.CO.NH_2 = H_2N.CO.NH.NH.CONH_2 + H_2N.NH_2$$

With nitrous acid it gives azoimidocarbonamide:

$$\left\{\begin{array}{r} H_2NCONH.NH_2 + ON.OH = H_2N.CO.NH.N:NOH + H_2O \\ H_2NCONHN:NOH = H_2N.CO.N\!<\!\!\begin{array}{c} N \\ \| \\ N \end{array} + H_2O \end{array}\right\}$$

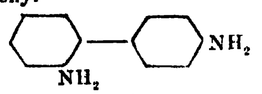
It is a very useful reagent for aldehydes and ketones, especially when these do not form well crystallised

oximes or hydrazones. To use it for this purpose the hydrochloride is employed (occasionally the sulphate must be used as with ionone); this salt is dissolved in a little water and its equivalent of an alcoholic solution of potassium acetate added; then the aldehyde or ketone added and more alcohol to complete the solution. The mixture is warmed, if necessary (*e.g.* with sugars and quinones); the time required varies from a few minutes to days. The products from aldehydes are called SEMICARBAZIDES, those from ketones SEMICARBAZONES. Semicarbazide is prepared by heating molecular proportions of urea and hydrazine hydrate in a tube at 100° for 20 hours; the contents are washed out with water and evaporated as far as possible on a water-bath; the viscous liquid so obtained crystallises on standing in a desiccator over sulphuric acid; the crystals are pressed on a porous plate and recrystallised from absolute alcohol. The hydrochloride is prepared by neutralising a solution of 13 grams of hydrazine sulphate in 100 cc. water with 5·5 grams dry sodium carbonate; when cool 8·8 grams of potassium cyanate are added and left 12 hours. The liquid is acidified with sulphuric acid and filtered from hydrazidodicarbonamide; the filtrate is shaken with benzaldehyde, when a precipitate of benzalsemicarbazide is obtained; this is filtered and washed with ether; then decomposed by cautious warming on the water-bath with concentrated hydrochloric acid (20 grams require 40 grams acid), and water added till all just dissolves. The warm liquid is shaken with benzene to remove benzaldehyde. The aqueous solution deposits the hydrochloride on cooling in small needles which form beautiful prisms when recrystallised from dilute alcohol; from the mother liquor more can be obtained by precipitation with benzaldehyde, etc. It can also be obtained by the electrolytic reduction of nitrourea in ammonium chloride solution, using wrought iron electrodes (70 sq. cm. of each immersed) and a current of 2 ampères for 20 hours; the cell stands in cold water. The product is precipitated with benzaldehyde, etc. The sulphate is made by decomposing acetone semicarbazone in alcoholic solution with the calculated quantity of sulphuric acid, when it separates out and is washed with alcohol.

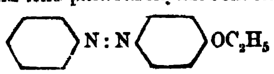
Semidemisemiquaver (*Music*). The name given to the note which is one sixty-fourth part of a semibreve, and to its equivalent rest. Also called a hemidemisemiquaver, *i.e.* a half-half-half-quaver. *See* NOTES *and* RESTS.

Semi-Diameter (*Astron.*) The distance from the centre to the circumference. Generally applied to the discs of the sun, planets, etc., or orbits.

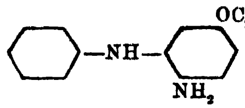
Semidine Transformation (*Chem.*) When azobenzene is reduced it yields hydrazobenzene, and the latter, when treated with an acid, yields benzidine (*see* HYDRAZOBENZENE). Besides the benzidine there is formed a smaller quantity of orthoparadiamidodiphenyl



In a compound like paraethoxyazobenzene

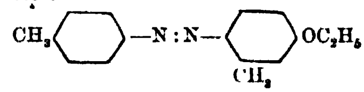


where the para position is occupied, a benzidine transformation cannot occur; reduction to the hydrazo-compound occurs, a little aniline and paraamidophenetole are formed; but the two principal products of the reaction are



and

These compounds are called SEMIDINES: the first is an orthosemidine and the second a parasemidine, and the reaction is known as the semidine transformation. With methylparaethoxyazobenzene the course taken by the semidine transformation depends on the position of the methyl group; when the methyl group is in any meta position to the azo group the reaction is similar to that which occurs when no methyl group is present and ortho-semidines are the chief product: when the methyl group is in an ortho position to the azo group parasemidines are the chief product. When both para positions and one ortho position are filled as in paratolueneazometacresetole



so that the parasemidine transformation cannot occur, then a little orthosemidine compound is formed, but the chief action is reduction to paratoluidine and ethoxyorthotoluidine. Now, as the orthosemidine transformation always occurs by the replacement of a hydrogen atom in the nucleus containing the ethoxy group, it is inferred that when a methyl group occupies an ortho position the space occupied by this group is a hindrance to another group entering an ortho position, and thus the parasemidine transformation occurs. (*See* Scholtz's "Raumerfüllung der Atomgruppen.")

Semi-Permeable Membranes *or* **Partitions** (*Chem.*) Membranes which, when they separate two solutions in the same solvent of different osmotic pressure, permit of the passage of the solvent, but not of the passage of the dissolved substance, from the solution of less osmotic pressure to that of greater osmotic pressure. The best semi-permeable membranes are the cell walls of certain vegetable and animal cells, such as the cells from the epidermis over the midrib of the violet or under side of the leaf of *Tradescantia discolor*, or the exterior cells of the spathe of *Curcuma rubicaulis*, or red blood corpuscles. The best artificial semi-permeable membrane is copper ferrocyanide. The action of the vegetable cells must be observed under the microscope. The action of the red blood corpuscles can be observed in a test tube. 0·5 cc. of defibrinated ox blood is put in a test tube containing about 20 cc. of a solution of potassium nitrate; if the strength of the nitrate is 1·04 per cent. or over, then on shaking and allowing to stand the corpuscles settle to the bottom of the tube, and the liquid above them is clear and nearly colourless; if the solution of nitrate is 0·96 per cent. or under, the clear layer standing over the deposited corpuscles shows a faint red colour—water with minute traces of hæmoglobin have escaped through the walls of the corpuscles. The artificial membrane is made by thoroughly soaking a porous pot in water, then in 3 per cent. solution of copper sulphate; after rinsing with water and drying with filter paper, a

3 per cent. solution of potassium ferrocyanide is poured in, and the pot stood in a solution of copper sulphate (3 per cent.) for a day or two; the latter process is repeated with the pot closed. To use the cell, a glass tube is sealed into it by sealing wax, the apparatus filled with the aqueous solution to be tested, the glass tube connected to a mercury manometer, and the porous pot stood in water. The copper ferrocyanide film deposited in the material of the porous cell will only hold for a few substances, such as the sugars and urea; for most substances it is useless for purposes of measurement. *See* OSMOTIC PRESSURE.

Semi-Porcelain (True). A class of ware coming between porcelain and earthenware in its characteristics. It is a "soft paste," more resonant than earthenware, absolutely non-absorbent, but only slightly translucent even when made very thin. Many so-called "semi-porcelains" are only "earthenwares." *See* POTTERY AND PORCELAIN.

Semiquaver (*Music*). The name given to the note which is one-sixteenth part of a semibreve, and to its equivalent rest. *See* NOTES *and* RESTS.

Semitone (*Music*). One-half of a tone. The semitone is the smallest interval recognised in practical music, and is that contained by two notes of the pianoforte next to each other, as from C to the black note next above, or from C to the white note next below it. Semitones are of two kinds: (1) Diatonic, when the notes are next to each other alphabetically, as E F, G A♭, *i.e.* when they are both contained in one diatonic scale. (2) Chromatic, when the notes are the same alphabetically, but altered by ♯, ♭, or ♮, as F F♯, G♭ G♮. *See* INTERVALS *and* SCALES.

Semplice (*Music*). Simple. *Semplicemente*, simply.

Sempre (*Music*). Always, as *sempre legato*, always (continued) smoothly and connected.

Senarmontite (*Min.*) A rare form of oxide of antimony, Sb_2O_3; cubic, in octahedrons; also in capillary masses. Colourless or grey. From Algeria and Hungary. *Cf.* VALENTINITE.

Sendal (*Archæol.*) A silken material of light texture, formerly used for banners and for dress.

Sender (*Elect.*) The instrument employed in transmitting a telegraphic message.

Seneca Oil. A synonym for Petroleum (*q.v.*)

Senega Root (*Botany*). The dried root of *Polygala senega* (order, *Polygalaceæ*) is used in medicine. It is imported from the United States.

Senna (*Botany*). *Cassia acutifolia* yields ALEXANDRIAN SENNA; *C. obovata* yields ITALIAN SENNA; and *C. angustifolia* the EAST INDIAN variety (order, *Leguminosæ*). The drug, which is used as a laxative, consists of the dried leaflets.

Sensibile (*Music*). Expressive.

Sensibility of a Galvanometer (*Elect.*) This term is used in various senses: *e.g.* (1) The deflection produced by a given current; (2) The current, or the reciprocal of the current, required to produce a given deflection.

Sensible Heat. Heat which can be perceived by the senses, owing to a change in temperature, as distinguished from LATENT HEAT (*q.v.*), which produces change in state without change of temperature.

Sensitive Flame (*Sound*). *See* FLAME, SENSITIVE.

Sentimentale; Sentimento, Con (*Music*). With feeling.

Senza (*Music*). Without; as SENZA REPETITIONE, without repeats. *See also* SORDINI.

Separately Excited Dynamo (*Elect. Eng.*) A dynamo whose field magnets are excited by current supplied from a separate source, *e.g.* another dynamo. *See also* DYNAMOS.

Separation Cake (*Chem. Eng.*) *See* SEEDING.

Sepiolite (*Min.*) A synonym for MEERSCHAUM (*q.v.*)

Septaria (*Geol.*) *See* CLAY IRONSTONE.

Septet, Septetto (*Music*). A composition for seven voices or instruments.

Septic Tank System (*Sanitation*). A system of treatment of sewage in which the sewage is collected in a covered tank somewhat resembling the old and discarded cesspool. The sewage is introduced below water level, and the outlet is also below the water line. The sewage is passed through the tank very slowly, and is acted on by micro-organisms which break up the solid matter. The advantage of this is that little or no solid matter is deposited. The effluent from the tank is then aërated by flowing over a weir in a thin stream, and is next passed through beds of coke. This system was introduced at Exeter in 1895 by the surveyor of that city, and it is claimed for it that the suspended matter is removed almost completely, and that in the tank itself over one-fourth of the organic carbon in the sewage is removed. In some later forms the submerged inlet is discarded, as it is said to produce more disturbance in the tanks. A separate sludge compartment with a sludge pump may also be provided. *See also* SANITATION.

Sequence (*Music*). The repetition of a musical figure at different pitch. Sequences may be of any length, and are of two kinds, Real and Tonal. A real sequence is one in which every interval of the figure is repeated exactly, and is chiefly made use of for modulation. A tonal sequence is one in which the repetition is confined to the same key; hence the intervals are not exactly repeated. The following shows one example of each kind of sequence.

REAL SEQUENCE.

TONAL SEQUENCE.

See also ROSALIA.

Serdab (*Architect.*) A secret chamber in an ancient Egyptian tomb. *See* MASTABA.

Sereno (*Mus.*) Tranquil.

Serge (*Woollen and Worsted Manufac.*) Serge is composed of crossbred worsted yarns, and is made in medium and heavy cloths for suitings and overcoatings. A union serge is one in which cotton warp and worsted weft is used. *See* WORSTED, *under* WOOL.

Seriatà, Con; Serio, Serioso (*Music*). In a serious, grave manner.

Series (*Elect.*) Conductors are said to be in SERIES when they are so connected that a current passes through them in succession, *i.e.* when the end of one conductor is connected to the beginning of the next.

Series Dynamo and Motor (*Elect. Eng.*) *See* DYNAMO *and* MOTOR.

Serif (*Typog.*) The fine lines and cross strokes on the top and bottom of certain styles of type, *e.g.* M. *Cf.* SANSERIF.

Serpent (*Her.*) The serpent as a charge is represented either erect, involved (in form of a circle), or nowed (tied in a knot).

—— (*Music*). A bass wooden instrument, bent in serpentine form, covered with leather, and having a cupped mouthpiece like a trombone. It is now nearly obsolete, its place being taken by the EUPHONIUM (*q.v.* p. 438). Amongst composers who made use of the serpent may be mentioned Mendelssohn in his *St. Paul*, etc.

Serpentine (*Geol.*) A soft rock capable of being easily carved into ornaments, and usually of a pattern reminding one of that found on some snakes. This colouring is developed chiefly by the prolonged exposure to sea water. Serpentine was in all cases originally an ultrabasic rock of eruptive origin. It consisted chiefly of Olivine and one or more of the Pyroxenes which have been subsequently hydrated by water circulating deep within the earth's crust. Serpentines may be of any age. Some Scottish serpentines are of Tertiary age.

—— (*Min.*) A hydrous silicate of magnesium with traces of alumina and ferrous oxide. It is a rock rather than a mineral. It results from the hydration of several ferromagnesium silicates in decomposition. It is much used as an ornamental stone. The chief British localities are Portsoy in Banffshire, the Lizard, the Shetland Isles, Anglesea, co. Galway, and co. Wicklow.

Serpollet Boiler. *See* BOILERS.

Serve Tube. A boiler tube having ribs radiating from the inner periphery of the tube, about a quarter of the diameter in length. They increase the surface, and hence the heat transmitting power of the tube. Compare the ROW TUBE, the principle of which is only applicable to flexible and ductile metals.

Service (*Plumb., etc.*) (1) The delivery of water or gas to a building. (2) SERVICE PIPES (*q.v.*)

Service Pipes (*Plumb., etc.*) The water or gas pipes inside a building are termed Service Pipes, and often alluded to collectively as the Service.

Service Reservoir (*Civil Eng.*) A reservoir from which water is supplied directly to a town; situated at a sufficient elevation to force the water to the top of the highest building. Their main objects are to provide a reserve of water for sudden emergencies (*e.g.* a fire, a broken main, etc.), and to enable a uniform pressure and a uniform rate of pumping to be maintained.

Service Tree (*Botany*). The true Service Tree is *Pyrus domestica*; the Wild Service Tree is *Pyrus torminalis*.

Serving. Covering the surface of a rope with yarn, etc., to prevent abrasion.

Servitor (*Glass Manufac.*) The glassmaker who fashions and forms the body of articles for the "workman" to finish. The second man in a set or "chair" of workmen. *Cf.* FOOT BLOWER *and* WORKMAN.

Sesame Oil. A medicinal oil expressed from the seeds of *Sesamum indicum* (order, *Pedaliaceæ*). The plant is cultivated in India.

Sesquialtera (*Music*). An organ pipe of several ranks (*see* MIXTURE).

Sestet (*Music*). A composition for six voices or instruments.

Set (*Carp., etc.*) The teeth of a saw are bent sideways; this is called the SET of the saw.

—— (*Typefounding*). The placing of letters or characters on the body or shank in such manner as will secure apparent uniformity of space between them when arranged in every possible form.

—— (*Typog.*) The term indicates the width of body of a type; this determines the amount of blank space on each side of a letter when printed.

—— *or* **Sett** (*Eng.*) (1) A deformation or deflection of an object, due to stresses. (2) A form of chisel with a handle used in cutting bars in the smithy.

—— *or* **Sett** (*Textile Manufac.*) The gauge of the cloth. The term has a different meaning in different centres. A 30s set Glasgow would be 30 × 40 in 37 inches; Bradford, the same number in 36 inches; and Dewsbury and the Heavy Woollen district in 90 inches. The more correct and simpler meaning is the number of reeds in one inch and the number of threads in each reed; *e.g.* 10s reed 4s equals a cloth of a set of 40 threads per inch.

Set *or* **Set Up** (*Typog.*) To place type in order so as to form words, etc., as represented by the copy (*q.v.*) for the purpose of printing; to compose.

Set Off (*Build.*) *See* OFF SET.

—— (*Plumb.*) A bend in a pipe.

—— (*Typog.*) Is caused when pressure is brought to bear on printed work before the ink is properly dry; *i.e.* the ink in its soft condition smears the sheet above or below.

Set Off Blanket (*Print.*) A blanket placed over the cylinders of a perfecting machine to absorb the surplus ink from the printed side of a sheet when being perfected up.

Set Off Paper (*Print.*) Paper to which some preparation has been applied, *e.g.* oil or glycerine; used to prevent the set off (*q.v.*)

Set Out (*Leather Manufac.*) *See* SETTING.

Set Screw (*Eng., etc.*) A screw used for adjusting some part of a piece of mechanism or for holding it in place when adjusted.

Set Square. A drawing instrument consisting of a right angled triangle made of wood, ebonite, etc. The acute angles are usually 60° and 30°, or both of 45°, but other angles are occasionally used.

Sett (*Build.*) A squared block of hard stone used for paving roads where the traffic is heavy. The stone is generally Dolerite, but granite is also used in many cases.

—— (*Textile Manufac.*) *See* SET.

Setter (*Pot.*) A shallow flat seggar in which, bedded upon ground flint, plates, dishes, saucers, and other flat ware are fired in the bisque oven (*q.v.*)

Setter Up (*Lace Manufac.*) A specialist who devotes his whole attention to the adjustment of the inside of a lace machine.

Setting (*Eng., etc.*) (1) Fixing the parts of machinery in their correct positions. (2) Bending the teeth of a saw. *See* SAW SETTING.

—— (*Leather Manufac.*) Leather in the wet state is laid flat on a table, and "set out" by means of a stone or metal slicker. The leather is stretched and set out until no growth marks or creases are visible and until quite flat. Also done by setting out machines.

Setting Block (*Eng.*) A block of iron with a curved edge, on which a saw is laid when the teeth are being set by hammering.

Setting Coat (*Plast.*) The finishing in two or three coat work.

Setting Hammer (*Eng., etc.*) A hammer with a thin pane or point, used for saw setting (*q.v.*)

Setting of Slide Valves (*Eng.*) *See* SLIDE VALVE.

Setting of Tools. *See* SHARPENING OF TOOLS.

Setting Out (*Carp. and Join.*) Marking lines on the prepared stuff (wood) for the cuts, grooves, and the various joints required in the construction of a piece of work. Preparing a working ROD (*q.v.*) from which the sizes of the various parts of the construction are ascertained and worked to.

—— (*Eng.*) Marking the lines, centres, etc., on a rough casting, forging, etc., preparatory to machining and fitting.

—— (*Surveying*). *See* RANGING.

Setting Over (*Eng.*) When conical or tapering work has to be turned in a lathe by means of the slide rest, the back centre or poppet is moved parallel to itself in a direction at right angles to the lathe bed, and fixed in such a position that the slant side of the conical piece of work lies parallel to the central axis of the lathe. This movement is termed Setting Over.

Setting Rule (*Typog.*) *See* COMPOSING RULE.

Setting Stick (*Typog.*) A COMPOSING STICK (*q.v.*)

Setting Stuff (*Build., etc.*) *See* FINE STUFF.

Settlement (*Build.*) (1) The term applied to the squeezing out of the mortar in the horizontal joints of brick and stone walls. (2) The general shrinkage which takes place in a new building.

Set Up (*Met.*) A machine for shortening and thickening a bloom that has been lengthened out by the squeezer.

—— (*Typog.*) *See* SET.

Set Work (*Eng., etc.*) Repetition work, *i.e.* the production of numbers of similar objects.

Seven Pound Lead (*Plumb.*) This expression means that one foot square will weigh 7 lb. The thickness of sheet lead is known by its weight per foot super.

Severies (*Architect.*) The cells or panels between the ribs in Gothic vaulting. *See* CELL *and* RIB AND PANEL VAULT.

Sèvres (*Porcelain*). The National Porcelain Manufactory of France originated at St. Cloud at the close of the seventeenth century. The manufactory proper was established at Vincennes in 1740. About twenty years later it was removed to Sèvres. It has always received Government support. Until the end of the eighteenth century Soft Paste was exclusively made, and it is celebrated as the finest type of soft paste extant. From about the year 1800 Hard Paste was produced, and it has been continued up to the present time. The most celebrated period of Sèvres Porcelain was the middle of the eighteenth century, when magnificent wares were produced, ornamented with rich chased gilding, combined with beautiful flower paintings and also paintings after Watteau and Boucher. The finest colours employed were dark blue (Bleu du Roi), turquoise, rose pink, and apple green.

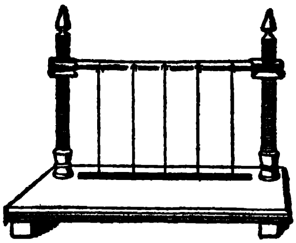
Sewage Removal and Disposal. *See under* SANITATION.

Sewer (*Sanitation*). According to the Public Health Act, 1875, a sewer means the channel receiving the drains of two or more houses or separate premises, and includes sewers and drains of every description, except drains to which the word "drain" as interpreted by the Act applies, and those under the control of any authority having the management of roads and not being a local authority under the Act.

Sewing (*Bind.*) This term comprehends the usual methods of fastening together in proper order the separate sections or sheets which make up a volume, the work being done on a sewing press or by a machine. The principal methods are known as (1) Flexible sewing and (2) Ordinary sewing. In the former method the thread with which the book is sewn is passed completely round each of the bands (*q.v.*) in the process of sewing, the bands being *outside* the sections. In the latter method the thread simply passes over and outside the bands, which are

"sawn in" to facilitate the process. Flexible sewing, therefore, is best adapted for books likely to be subjected to much usage. *See* BOOKBINDING; KETTLE-STITCH; OVERSEWING; SAWING IN; SEWING PRESS; STABBING; *and* STITCHING.

Sewing Press (*Bind.*) An apparatus on which the sections (sheets) forming a volume are placed to be sewn together by hand. The five strings seen in position are the cords or bands (*q.v.*) which are fastened at the top to loops on the crossbar termed lay cords, and are fixed at the other end by means of small implements called keys, which pass through the slot in the bed of the press.



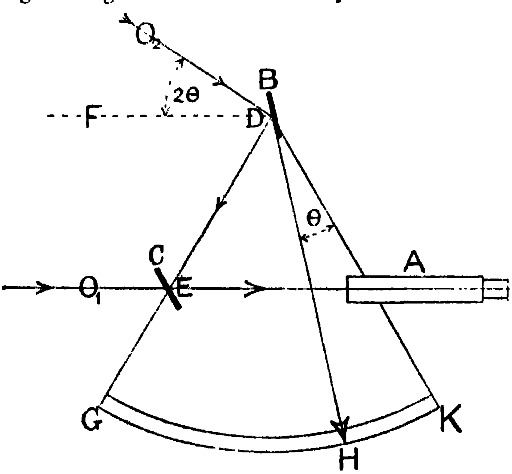
SEWING PRESS.

The sections are placed in one at a time, in numerical order, on the bed of the press with the backs against the cords. The threaded needle, being inserted at the top of the page, is passed along the inside of the fold of the section by the left hand until it is opposite the various bands, when it is thrust through the paper, and the thread is either passed completely round, *i.e.* encircles the band, as in the case of Flexible sewing (*see* SEWING), or simply passes outside the band before re-entry, as in Ordinary sewing.

—— *See* SEWING, KEY, *and* LAY CORD.

Sexpartite or Sixpart Vault (*Architect.*) One of the earliest forms of rib and panel vaults. It was used before the introduction of the pointed arch overcame the difficulty of constructing vaults over spaces which were not square on plan. In a sexpartite vault two bays of the aisle are included in one of the nave. The vault over each rectangle is divided into six compartments by ribs, and all the ribs are arranged as semicircles. *See* RIB AND PANEL VAULT *and* QUADRIPARTITE VAULTING.

Sextant (*Optics, etc.*) An instrument for measuring the angle subtended at the eye of the observer



SEXTANT.

by two distant objects. Let O_1 be a ray from the first object; the telescope A is placed so as to receive this ray directly. O_2 is a ray from the second object, falling on a movable mirror B, by which it is reflected to the mirror C, and thence to the telescope. C is silvered on one-half of its surface only, in order that the ray O_1 may be transmitted through one-half along the path O_1A; while the ray O_2 is reflected by the other half along the path DEA. An arm DH, turning on an axis at D, carries the mirror B. If the ray O_2 be parallel to O_1, the mirror B must be placed parallel to C; H then coincides with the zero of a graduated scale engraved along GHK. If B has to be turned through an angle KDH, in order to reflect the ray O_2 along the path DEA, then the angle O_2DF, which is the angle between the rays O_1 and O_2, is twice the angle HDK. Each degree on the scale GK is numbered as two degrees, and the angle required can then be read off at once. The instrument derives its name from the fact that the arms DK and DG are at an angle of 60° with each other. In an older form these arms were at right angles, and the arc GH was a quarter of a circle; this type was termed a QUADRANT. The instrument is used at sea to measure the angular distance between two celestial bodies, or between one such body and the horizon. Its most important use is to find when the sun reaches its greatest altitude; the instant when this occurs is the time of the sun's Transit (*see* TRANSIT), that is, the time of apparent Solar Noon. This time is reduced to the Mean Noon, and by comparison with the chronometer, which shows the exact mean time at Greenwich, the longitude can be found.

Sextet (*Music*). *See* SESTET.

Sextuplet (*Music*). A group of six notes to be performed in the time of four.

Sforzando, Sforzato (*Music*). Forced, accented. Usually abbreviated to *sf* or *sfz*. Applies to single notes or groups of notes which are to be strongly emphasised. *Cf.* RINFORZANDO.

Sfregazzi (*Paint.*) The Italian term for the method of shading employed by the Venetian school of painters. It consisted of dipping the finger in colour and drawing it once over the part to be shaded, the result being a soft and uniformly thin shadow.

Sgraffito (*Architect.*) A method of treating a small surface, consisting in covering a coloured plaster with a white coat, and then forming the design by scratching away parts of the latter and exposing the ground.

—— (*Dec.*) A method of decoration effected by drawing black figures on a white ground, or *vice versa*, the outlines being accentuated by hatchings. Often carried out in stucco. *Cf.* GRAFFITO.

Shackle (*Eng., etc.*) A loop at the end of a bolt, etc., to which a hook or chain can be fastened.

Shackle Insulator (*Elect. Eng.*) An insulator fixed between the ends of two wires or the two ends of a cut wire.

Shade (*Art*). (1) A gradation of colour. (2) The parts of a picture or drawing represented as unilluminated. (3) A colour to which black has been added. Just as white when added to a colour in different proportions gives a variety of tints, so when black is added the result is a variety of shades. When a colour is viewed in a somewhat dark room, it has the appearance of a shade as compared with the appearance the colour would present if viewed in a strong light. *See* COLOURS, HUE, TINT, *and* CHIAROSCURO.

Shading (*Art*). The method of representing shadows, or obtaining relief, effected by gradations of colour tones or hatching. *See* CHIAROSCURO *and* HATCHING.

—— (*Eng.*, *etc.*) Shading is used in mechanical drawings both to give a natural appearance to views showing the external surface of an object, and also to indicate on a section the material of which the object is composed. Various conventional methods of shading are used for this purpose. *See* SECTION.

Shadow. The region of apparent darkness on a surface, due to the interception of light by an opaque body, the shadow being an outline of the illuminated portion of the intercepting body.

—— (*Phys.*) An area or space within which illumination from some particular source or sources is cut off by an opaque object. The term is further extended in physics to the cutting off of other forms of radiation and radiant energy. Thus the cutting off of heat rays produces a shadow whose boundaries may be detected by the use of the thermopile. A sound shadow may be detected in some cases by the ear, in other cases by the use of the sensitive flame, etc.

Shadow Bands (*Astron.*) The curious appearance of dark and light bands which are observed to travel on the surface of objects during the commencement and end of the total phase of an eclipse of the sun.

Shadow Photometer (*Light*). *See* PHOTOMETERS.

Shaft (*Architect.*) The central division of a column between the base and capital. *See* COLUMN *and* ARCHITECTURE, ORDERS OF.

—— (*Eng.*) A rod or bar, usually cylindrical, which is used to transmit rotation.

—— (*Mining*, *Civil Eng.*, *etc.*) A vertical (less frequently inclined or sloping) hole leading into a mine, tunnel, or other underground working. The sides are lined with timber, masonry, or iron, to prevent collapse. The shaft may be intended solely for ventilation, or may contain ladders, winding gear, pumping appliances, etc. *See* MINING.

—— (*Silk Manufac.*) *See* HEDDLE.

Shafting (*Eng.*) A comprehensive term for a number of shafts; often used to include their bearings, pulleys, etc.

——, **Flexible** (*Eng.*, *etc.*) Shafting made of some flexible material, or constructed with joints which permit lateral bending while rotary motion is being transmitted, are used to actuate certain kinds of mechanism, *e.g.* small drills such as those used by dentists. A flexible shaft is also used in certain cases where a very high velocity of rotation occurs, as in some forms of steam turbine, in order to diminish the risk of fracture.

Shaft Tunnel (*Eng.*) The passage or tunnel through which the shaft of a screw propeller runs from the engine to the stern of the vessel.

Shake (*Carp.*, *etc.*) Cracks or fractures produced in timber, due to shrinkage. *See* WOODS.

—— (*Mining*). A crack or opening in a vein or rock.

—— (*Print.*) An imperfect impression caused by a defect in the press or machine, and giving a blurred appearance to the printing.

—— *or* **Trill** (*Music*). *See* ORNAMENTS, p. 478.

Shale (*Geol.*) Sedimentary rocks originally deposited as thin layers of mud or silt, with pauses between the deposition of each layer, so that slight differences of mineral character occur at small vertical intervals, and the rock, in consequence, splits easily in directions parallel to them. In Scotland Shales are called Blaes. In the North of England they are called Plate, and, if silicious, Shiver. Shale in Scotland usually means Oil Shale (*q.v.*) *Cf.* SCHIST.

Shallow Water Deposits (*Geol.*) Sedimentary rocks deposited in water of small depth, which commonly alternate with other sediments that have been formed at the surface. The prevailing types are shingle and gravel, coarse and fine sands, silts and loams, with, more rarely, clays. Limestones seldom occur; but shell marl, and also diatom earth, may form part of shallow water deposits of freshwater origin. Impressions of raindrops and casts of desiccation cracks formed by the drying of clay beds, etc., are specially characteristic of shallow water deposits. Ripple marks also are of common occurrence.

Shallow Wells (*Economic Geol.*) This term should be understood to mean wells where water supplies are chiefly drawn from waters percolating into them directly from the surface, as distinguished from those wells whose supply is exclusively derived from waters which have circulated through the solid rock. A well supplied from the water which generally occurs at the bottom of the river gravels of the Thames Valley is a good example of the former; while a well sunk deep into the chalk of the same district, and exclusively supplied from that source, is a typical example of the latter. Shallow wells are particularly liable to surface contamination from middens, cesspools, drains, and other sources of pollution, and are often, therefore, dangerous sources of disease. In those wells in which proper care is taken to exclude all surface waters, no such danger can exist, even though their actual depth may be but small. On the other hand, a well of considerable depth, if surface waters are not rigidly excluded, may at any time prove to be a source of danger. *See also* SANITATION.

Shamrock (*Botany*). *Trifolium repens* (order, *Leguminosæ*), a plant common in most temperate regions. The original shamrock is believed by some writers to have been *Oxalis acetosella*.

Shank. (1) A handle. (2) In the foundry a bent bar serving as a support for a ladle. (3) The main part or body of a tool such as a drill, slide rest, tool, etc. *Cf.* TANG.

—— (*Join.*) The straight part on the end of a wreathed handrail.

—— *See* TYPES.

Shap Granite. *See* BUILDING STONES.

Shaping (*Eng.*) Work carried out in the SHAPING MACHINE (*q.v.*)

Shaping Machine (*Eng.*) A machine tool in which a tool resembling that used in a slide rest is moved backward and forward in a horizontal line, so as to act on a piece of work fixed upon the table of the machine. Its cutting action is similar to that of a planing machine, but it is more convenient for use in the case of small or awkwardly shaped objects.

Sharp (*Music*). Marked by ♯. It raises the note before which it is placed a semitone. *See also* DOUBLE SHARP.

Sharpened 5th (*Music*). The chord consisting of the Dominant, Leading-note, Sub-dominant, and sharpened Supertonic, so called by Theorists opposed to the Day theory (*q.v.*)

Sharpening of Tools. This includes (1) GRINDING on a grindstone or emery wheel, or an equivalent operation, in order to bring the edge approximately to the required form (2) SETTING or sharpening proper, in which the final form is given to the cutting edge by oil stones or hones. The final setting is as important in the proper sharpening of tools for cutting metal as in the much keener edges used in woodwork, if a good finish or accurate work is required.

Sharpening Slip (*Carp., Eng., etc.*) A piece of stone for sharpening or setting the edges of curved cutting tools.

Sharpe's Classification (*Architect.*) *See* CURVILINEAR.

Sharp Mixture, Shrill Mixture (*Music*). One of the stops in organs. *See* p. 439.

Shave Hook (*Plumb.*) A scraper for shaving off the lead where a joint has to be made.

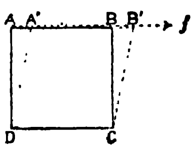
Shaving (*Leather Manufac.*) Hides and skins for certain purposes are shaved to even substance. This is one of the most delicate operations in finishing leather. The operation is mostly done by hand on an upright beam with a knife, the edge of which has been turned at right angles. For rough work machines are now used.

—— (*Plumb.*) Paring away the surfaces from two pieces of lead that are to be soldered together.

Shaving Tub (*Bind.*) The receptacle into which the paper falls when the edges of a book are being cut previous to binding.

Shawm *or* **Shalm** (*Archæol.*) That mentioned in the Prayer Book is, according to the late Sir John Stainer, the ramshorn or horn trumpet.

Shear (*Phys., Eng., etc.*) Let A B C D be any piece of material, with the edge D C rigidly fixed. Let a tangential force, whose amount is f units of force per unit area, be applied to the face A B in the direction of the arrow. Then the material will in general be distorted into the form A′ B′ C D. The angle A D A′ or B C B′ is termed the SHEAR *or* SHEARING STRAIN, and the force f the SHEARING STRESS.



SHEAR.

A shear can be produced without alteration in the volume of a body, as, for example, when one end of a cylindrical rod or wire is rigidly fixed, and the other end twisted. This is the form of stress which exists in shafts which are used to transmit any rotary motion. The ratio

$$\frac{\text{Shearing Stress}}{\text{Shearing Strain}}$$

is termed the COEFFICIENT OF RIGIDITY, COEFFICIENT OF TRANSVERSE ELASTICITY, MODULUS OF RIGIDITY, or simply the RIGIDITY.

Shearing (*Eng.*) (1) Cutting material by means of shears or a shearing machine. (2) The production of a Shearing Stress or Strain. *See* SHEAR.

—— (*Geol.*) A term applied to the mechanical results upon rocks resulting from a differential movement of the part on one platform as compared with that immediately below. The phenomenon is one that usually accompanies great terrestrial disturbances deep within the earth's crust.

Shearing Machine (*Eng.*) A machine driven by power and provided with strong jaws or knives for cutting iron plates or bars. Largely used in boiler shops, etc.

Shearing Strain (*Eng.*) *See* SHEAR.

Shearing Stress (*Eng.*) *See* SHEAR.

Shear Legs (*Eng.*) *See* SHEERS.

Shears. Cutting tools for sheet metal, glass, etc., having a mode of action resembling that of scissors; the tool may be actuated by hand or power; in the latter case it is usually termed a SHEARING MACHINE *q.v.*)

Shear Steel (*Met.*) Steel which has been formed from a number of bars of common steel made into a FAGOT (*q.v.*) This is heated to the welding temperature and drawn out. If the operation is repeated DOUBLE SHEAR STEEL is produced.

Sheave (*Eng., etc.*) (1) A small wheel with a groove in its periphery in which a rope or belt can run. (2) The central portion or disc of an ECCENTRIC (*q.v.*)

Shed (*Textile Manufac.*) The space or opening between warp threads when they are separated for the shuttle to pass through. *See* OPEN SHED, CLOSED SHED, *and* LOOM.

Shedding (*Textile Manufac.*) The primary movement of the loom. The formation of a division or "shed" in the warp threads by the healds to allow the shuttle to pass through, so as to effect an interlacing of warp with weft. The shedding motions are: TAPPET, DOBBY, JACQUARD (*q.v.*) *See also* LOOM.

Sheep (*Bind.*) The term applied to various cheap kinds of binding done with sheepskin.

Sheepsfoot (*Print.*) A hammer with an iron handle which has a claw at the end. The hammer is used for fastening formes in the press, and the claw for raising the formes

Sheer Poles (*Eng.*) The poles of a set of SHEER LEGS: SHEERS.

Sheers. A tall hoisting apparatus consisting of two or three pieces of timber, etc., erected so as to incline towards each other at the top, where they are fastened together and the necessary tackle for hoisting attached. Sheers are employed for masting and dismasting ships, putting in marine boilers and engines and other similar operations.

Sheet (*Print.*) The perfected section of a printed work, *i.e.* printed from outer and inner formes.

Sheet Glass. This is used chiefly for glazing, and has entirely superseded Crown glass for the purpose, owing to reduction of waste and the larger size of the sheets. Figured rolled sheets of various colours and patterns are manufactured in a manner similar to rolling plate glass, the pattern being incised upon the roller. These sheets are cut up into shapes suitable for designs in leaded lights. *See* FURNACE, GLASS MANUFACTURE, *and* CROWN GLASS.

Sheet Iron (*Eng., etc.*) Thin plates of iron, such as are used for making TIN PLATES (*q.v.*) The thicker plates (those above ¼ in.) are not termed sheet iron, but BOILER PLATES, etc.

Sheet Lightning (*Meteorol.*) A sudden glow which is not confined to a line, as in the case of

ordinary lightning. It is probably the reflection of a more distant flash of ordinary lightning occurring in many cases below the horizon.

Sheet Metal Gauge (*Eng.*) A flat plate with notches, whose width serves to determine the gauge or thickness of sheet metal. The width of the notches may correspond to the numbers of the various WIRE GAUGES (*q.v.*) or may be definite fractions of the inch, etc.

Sheet Piling (*Civil Eng.*) Piles driven into the ground close together, so as to form a continuous row. They are usually braced together, and the joints filled up by caulking, in order to form a water-tight partition. In large works two parallel rows of sheet piling are used, and the space between them is filled up with clay.

Sheet Tin (*Met.*) This term is applied to thin plates of good wrought iron or mild steel, coated with metallic tin. *See* TIN PLATES.

Shell (*Eng.*) The outer part of various objects, *e.g.* of a boiler, considered apart from its fittings, or of a ship, apart from the internal work, machinery, etc.

Shellac. A brittle resinous substance produced by an insect. It consists of about 85 per cent. resin, 5 per cent. wax, colouring matter, etc. There are six varieties in commerce, viz. stick lac, lac dye, shell lac, seed lac, button lac, and shellac rods. It is largely used in the manufacture of wood polishes and of spirit and other varnishes. *See* LAC *and* RESINS.

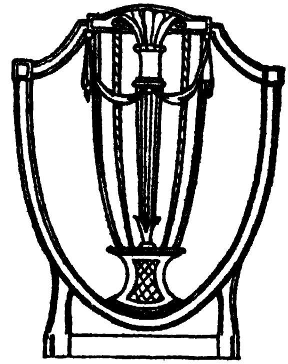
Shell, Magnetic. *See* MAGNETIC SHELL.

Shell Marl (*Geol.*) Usually a freshwater deposit formed at the bottom of quiet sheets of water, and consisting partly of the dead shells of freshwater mollusca, but mainly of a mixture of fine clay and calcareous matter resulting from chemical precipitation. The word "marl" properly means any rock that readily crumbles away on exposure to the weather. *See* MARL.

Shell Plates (*Eng.*) The plates composing the outer part or shell of a boiler.

Shell Transformer (*Elect. Eng.*) *See* TRANSFORMERS.

Sheraton. In this country Sheraton furniture stands next in repute to Chippendale. Though not so original as his predecessor, Thomas Sheraton showed more skill in the adaptation of French forms, *viz.* Louis Seize and Empire; hence his work covers a wider field. Sheraton was born at Stockton-on-Tees in 1751, came to London in 1790, and the following year published *The Cabinetmaker and Upholsterer's Drawing Book*, which was succeeded by an accompaniment and an appendix. The second edition of this standard work appeared in 1793, and the final one in 1802. In 1803 was issued *The Cabinet Dictionary; or, Explanation of All Terms used in the Cabinet, Chair, and Upholstery Branches*, and next year he commenced the publication in serial form of *The Cabinetmaker and Artist's Encyclopædia*, to be completed in 125 parts, of which but thirty were before the public at the time of his demise in 1806. Sheraton was trained for the profession of an architect, and his studies proved of great value in his life work. His designs are drawn to scale with mathematical precision, and he effected a meritorious combination of such diverse styles as those of Louis XVI., Sir W. Chambers, and the brothers Adam; he also rendered in wood the famous Queen Anne swan-necked pediments. Sheraton's designs comprise painted wood mantelpieces, drawing-room panels, pier tables, square mirrors, door cases, cornices in the aforenamed blends, satinwood cabinets, clock cases, commodes, toilet tables, Pembroke tables and chairs. The satinwood pieces were painted in devices of wreaths, floral and ribband festoons, cornucopiæ, medallions, trophies, and allegorical figures. There is a beautiful toilet table (No. 635) at South Kensington in the latter style. For his veneers Sheraton used the most costly mahogany; for inlays, purple wood, box, and occasionally stained woods. To divide his panels he employed the Ionic pilaster. Among the novelties which we owe to Sheraton may be named the kidney shaped writing table; the sideboard with concave fronts, for which the serpentine form was occasionally substituted; and last, not least, "Rudd's Table," for toilet purposes, fitted with a central and two flanking mirrors, which last, rising by a quadrant, could be turned from a vertical to a horizontal position, thus reflecting the back of the head. A reversion in the type of chairs favoured by him was that to the ancient classic curule, the seats ornamented with masks of men and animals. The metal employed for the Empire work was brass; unfortunately this led him to decorate his carved wood pieces with bronze green or gilt. The effect after lapse of time proves this to be a serious error, as may be seen in Nos. 45 and 46 at South Kensington. The only other specimens of Sheraton at this Museum are Nos. 407 and 408, a pair of marqueterie chairs. Among the curiosities devised by Sheraton may be mentioned "gouty stools," chamber horses, "library steps planned to fold up within the Royal writing table," *bidet* dressing tables transformed by closing into stands, and "a pulpit with inlaid panels and a sounding board surmounted by an acorn shaped ornament." Sheraton's *magnum opus*, *The Cabinetmaker and Upholsterer's Drawing Book*, was republished in 1895 by Messrs. Batsford.



CHAIR BACK (SHERATON).

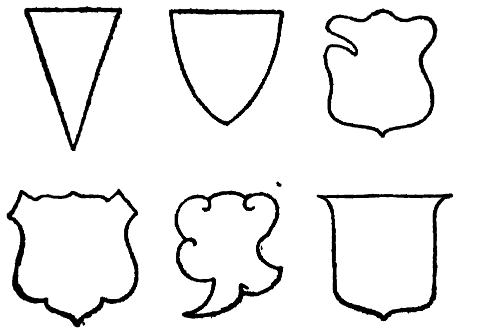
Sheringham Valve. This ventilator consists of a small vertical trap door (usually 9 in. by 3 in.) in the wall near the ceiling, hinged at the bottom and cased at the sides, so that the air, which enters through a perforated brick or grating, is directed upwards. It can be opened or closed by means of a balanced weight.

Shield (*Arm.*) A piece of defensive armour made of wood, hide, or metal, or a combination of these substances. It was carried on the left arm, and used for warding off blows or missiles. The earliest known examples are circular in shape and almost flat on the outside; they date from the Bronze age. The shield continued in use until the sixteenth century, by which time firearms had rendered it practically useless. The Norman shield was triangular or kite shaped, eventually becoming shorter and convex on the outside, *i.e.* curving towards the body, the latter form being known as a "heater" shield. *Cf.* SCUTUM.

Shield (*Civil Eng.*) A structure used in the excavation of tunnels, especially through loose or wet strata. The outline commonly follows the shape of the tunnel; it supports the roof and protects the men who work inside the shield. As the material in front is removed, the shield is pressed forward by rams or other mechanism, and the masonry of the tunnel is filled in behind it. In some cases the shield itself carries mechanical excavating appliances, driven by power.

—— (*Eng.*) In general a cover or screen employed to protect some part of a machine or to guard workmen from injury by the mechanism.

—— (*Her.*) The escutcheon upon which heraldic charges are blazoned. The space enclosed by its bounding lines is termed the *Field*, the colours used in the field are termed *Tinctures*, the lines used in dividing the field are termed *Partition Lines*, and the various objects which appear on the field are known as *Charges*. The heraldic shield or escutcheon has assumed various forms at different periods. The



5 6

1. Triangular Shield.
2. Heater shaped Shield.
3. Shield *à bouche*.
4. Shield of Georgian period.
5. Rococo Shield.
6. Modern Shield.

most ancient are simple, but in later times their outlines became more elaborate. The custom of blazoning arms on shields arose in the Middle Ages, when nobles and knights in armour bore devices on their shields in battle for the purpose of distinction. *See* HERALDRY *and* POINTS OF SHIELD.

——, **Electric and Magnetic.** *See* SCREEN, ELECTRIC AND MAGNETIC.

Shielding, Electric and Magnetic. The action of an electric or a magnetic screen. *See* SCREEN.

Shield of Pretence (*Her.*) A small shield bearing an escutcheon is in some cases placed upon the centre of another shield. The shield of an heiress is sometimes thus "pretended" upon the arms of her husband. The arms of Hanover were placed on a shield of pretence on the Royal Arms of England during the reigns of the kings of that house.

Shifting Link (*Eng.*) The slotted link to which the ends of the eccentric rods are attached. *See* LINK MOTION.

Shingle (*Geol.*) A term that ought properly to be restricted to the accumulation of rounded stones worn by the prolonged action of water in motion, which would leave the term gravel for the angular and subangular stones such as floor so much of the Thames Valley and the Basin of the English Channel.

Shingler (*Met.*) A workman employed in SHINGLING (*q.v.*)

Shingles (*Build.*) Boards of V-shaped section, commonly ½ to 1 in. thick at one edge, but tapering towards the other edge. They are made from some wood which splits easily along the grain, such as some species of oak. Used for roofing, fencing, etc.

Shingling (*Met.*) The squeezing and hammering of the ball of spongy iron from the puddling furnace to weld the iron into a bloom or stamp and expel slag, etc.

Ship Canal (*Civil Eng.*) A canal intended for the passage of ships; chiefly differs from an ordinary canal in its greater size, and in the fact that it must be constructed at a low level without embankments. The Suez Canal was originally 26 ft. deep, but this has been increased; most modern ship canals are about 30 ft.

Shippers (*Build.*) A term now frequently used for sound, hard burnt bricks, but of a bad shape.

Shipping. (1) Placing on board ship. (2) A general term for putting in place some movable object, *e.g.* placing a belt on the pulleys.

Shipping Measurements. The extreme length, breadth, and depth of an object measured to the extremities of all projections; they may be taken as approximately equal to the size of the box which would contain the entire object. Shipping charges are based on this size, and not on the actual bulk or weight of the goods.

Ship Plates (*Eng.*) Iron or mild steel plate not of the best quality, but of sufficient tensile strength for use in the hulls of ships.

S.H.M. SIMPLE HARMONIC MOTION (*q.v.*)

Shock (*Eng.*) A sudden stress, whether produced by a blow or otherwise.

——, **Electric.** The effect produced on a living organism by the passage of electricity through the tissues.

Shoddy. Coarse and inferior cloth, composed of the fibre of old woollen or worsted fabrics which have been torn up or "devilled" and respun with the admixture of fresh wool of inferior quality.

Shoe (*Build.*) The lower end of a rain water pipe shooting out from the wall.

—— (*Eng.*) A metal cap placed on the end of beams and poles to prevent undue wear or to facilitate the attachment of other objects, etc.

—— (*Glass Manufac.*) A fireclay box placed on one side of the pot and projecting into the furnace. Used for heating the gathering irons and ponty.

Shone System (*Sanitation*). This system of sewage removal is useful where the ground is flat and there is difficulty in getting a fall. The sewage is collected in cylindrical reservoirs, known as "ejectors," and forced from these tanks through pipes to the outfall by means of compressed air.

S-Hooks (*Foundry*). Iron hooks hanging inside moulding boxes and serving to support the sand.

Shoot (*Silk Manufac.*) *See* WEFT.

Shooter (*Typog.*) *See* SHOOTING STICK.

Shooting (*Joinery, etc.*) Truing the faces or edges of boards, etc., by means of the trying plane.

Shooting Board (*Joinery, etc.*) A board on which a piece of wood is laid when an edge, etc., is being accurately planed. The wood is placed on the shooting board with the edge required to be trued up

projecting over a rabbet or depression, along which the plane is moved. The edge of this depression guides the plane in a straight line.

Shooting Stars (*Astron.*) *See* METEORS.

Shooting Stick (*Typog.*) An implement made of wood, steel, or other hard material, and used in conjunction with the mallet for locking up formes of type.

Shop Front (*Carp. and Join.*) The whole of the front of a shop, etc., woodwork, from the cornice to the pavement.

Shop Tools (*Eng.*) The smaller articles provided by the owners of the workshops, as distinguished from the machine tools on the one hand and the tools which are the private property of the workmen on the other.

Shop Traveller (*Eng.*) A travelling crane used for lifting heavy objects in the workshop. Usually fitted in every department of the engineering shop except that of the pattern makers.

Shore (*Geol.*) The zone between tide marks, which is that of the greatest biological activity, as well as that along which marine erosion chiefly operates.

——, **Shoring** (*Carp.*) Shoring is a method of furnishing temporary support to walls or other parts of a structure during alterations or excavations which affect their stability, or when they show signs of yielding from other causes. For this purpose timbers termed SHORES are used. An inclined support, reaching from the ground to some point in the wall, etc., is termed a RAKING SHORE. Two or more raking shores extending from the same point (or nearly so) on the ground to different points on the wall, form DOUBLE RAKING SHORES, TREBLE RAKING SHORES, etc. An inclined support extending from a point on a shore to some point on the wall above is termed a RIDER. The lower end of a raking shore rests on a flat timber termed a SOLE PIECE or FOOT BLOCK; the upper end rests against a flat timber placed vertically against the wall, and termed a WALL PIECE. Into this wall piece is mortised a rectangular piece of wood termed a NEEDLE; one end of this passes through the wall piece into the wall itself, the other projects sufficiently to enable the top of the shore to abut against it. A FLYING SHORE is a horizontal support extending between two walls, the ends abutting on wall pieces. DEAD SHORES are vertical timbers supporting the masonry over an opening (*e.g.* a shop front). The feet of these shores rest on SLEEPERS or FENDERS, horizontal timbers laid on the ground, and their tops carry transverse members (termed NEEDLES) on which the masonry rests. The adjustment of shoring is largely effected by wedges, and the joints are secured by iron dogs, hoop iron, or additional wooden members nailed or spiked to the main timbers.

Short (*Elect.*) A contraction for SHORT CIRCUIT (*q.v.*)

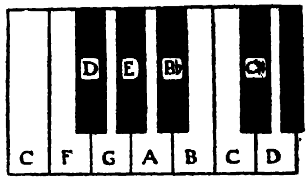
—— (*Met.*) Brittleness in metals, especially iron and steel, due to the presence of certain impurities. *See* COLD SHORT *and* RED SHORT.

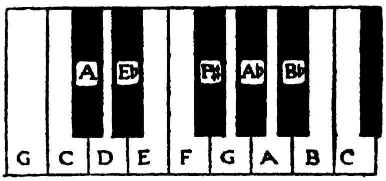
Short Circuit (*Elect.*) An electrical connection between two points in a circuit which provides an alternative path for the current, and thereby diverts it from the main circuit to a greater or less extent.

Short Column (*Eng.*) A column whose diameter is a large fraction ($\frac{1}{8}$ to $\frac{1}{4}$) of its length, and whose tendency to bend under its load may therefore be neglected.

Short Cross (*Typog.*) The shorter and usually the broader bar which divides the inner space of an ordinary book chase.

Short Octave (*Music*). A term given to organs which had an incomplete scale at the lowest end of the manuals. The notes were arranged to give as many "tonics" as possible without the expense of adding the larger pipes of the complete chromatic scale. The order of the sounds differed, but the following shows two arrangements of the notes:





Short Period Comets (*Astron.*) Comets which have periods from three to eight years in length. Spoken of sometimes as Jupiter's family of comets.

Shorts (*Typog.*) A term applied (*a*) when the printed sheets are less than the number required; (*b*) to describe the accented vowels ă ĕ ĭ ŏ ŭ.

Shot Edges (*Carp. and Join.*) The edges of a board which have been planed straight by the process of SHOOTING (*q.v.*)

Shoulder (*Eng., Carp., etc.*) The part of an object at which there is a sudden increase in width or diameter. The term is often restricted to the surface at this point, which is at right angles to the main axis of the object, *e.g.* the portion of a tenon joint which forms the abutment.

Shouldered Arch (*Architect.*) A lintel over a door opening resting on two projecting corbels; a common method of construction in Early English work.

Shoulder Notes (*Typog.*) Notes placed in the margin at the top of a page. *See* NOTES.

Shoulder of Type. *See* TYPES.

Shoulder Plane (*Join.*) A metal rabbet plane for shooting the shoulders of tenons, etc.

Shove *or* **Shive** (*Linen Manufac.*) When the flax is being scutched in order to separate the fibre from the bone or woody stem, the latter is broken up and driven out by revolving blades, and a large quantity of refuse is thus produced which is called "shove" or "shive." It is often, after the tow or short fibres are extracted from it, burned in the scutch mill fires.

Showers, Meteoric (*Astron.*) *See* METEORS.

Shrine. A casket or other receptacle for sacred relics, or a small chapel, etc., sanctified by the presence of such relics. An altar.

Shrinkage (*Foundry*). The contraction of a casting while cooling.

Shrinking Head (*Foundry*). A FEEDER (*q.v.*)

Shrinking On (*Eng.*, *etc.*) Fixing on a tyre, etc., which is made slightly smaller than the wheel to which it belongs. By heating the tyre it expands sufficiently to allow it to be placed in position, and its contraction on cooling holds it firmly in place.

Shroud (*Eng.*) A flange connecting the ends of the separate teeth of a gear wheel. A FULL SHROUD is one whose depth is equal to that of the teeth, so that the latter do not project at all. The wheel gearing with the fully shrouded one will therefore have no shroud. A HALF SHROUD, or flange of half the depth of the teeth, may be employed in the case of both wheels. A shroud increases the strength of the teeth to a very considerable extent, but is difficult and expensive to cast, and the teeth cannot be cut or finished by the aid of rotary cutters. The term "shroud" is also applied to the flanges which support the floats of a waterwheel.

Shrouded Wheels (*Eng.*) Toothed wheels provided with a SHROUD (*q.v.*)

Shunt (*Elect.*) A branch conductor or circuit connected in parallel (*q.v.*) with another or main circuit between two given points. The current divides itself between the two branches in proportion to their conductivity. A shunt may be used for various purposes, *e.g.* to draw off a portion of the main current for some specific purpose, as in the Shunt Dynamo (*q.v.*), or merely to reduce the current in a part of the main circuit, as in the case of a galvanometer. In this instance a shunt is used when the current is too large to be passed through the instrument with safety, or too large to give a readable deflection. If G be the galvanometer resistance, S that of the shunt, the fraction of the current which passes through the galvanometer is $\frac{S}{S+G}$. It is usual, where the amount of the current has to be found, to make S $\frac{1}{9}$, $\frac{1}{99}$, or $\frac{1}{999}$ of G, when ·1, ·01, or ·001 of the main current passes through the instrument. The factor by which the current through the galvanometer must be multiplied in order to obtain the total current is often termed the MULTIPLYING POWER OF THE SHUNT.

Shunt Dynamo (*Elect. Eng.*) *See* DYNAMO.

Shunting (*Elect. Eng.*) Providing or using a SHUNT (*q.v.*)

—— (*Railways*). Diverting rolling stock from one set of rails to another.

Shunt, Multiplying Power of (*Elect.*) *See* SHUNT.

Shunt Wound Dynamo (*Elect. Eng.*) *See* DYNAMO.

Shutter Weir (*Civil Eng.*) A weir consisting of panels or shutters turning about a horizontal hinge, usually placed a little above the centre. When the weir is closed, the top of the shutter is inclined down stream, and the bottom rests against a sill or ledge in the bed of the stream.

Shutting (*Eng.*) Closing up a joint by welding or hammering.

Shuttle (*Weaving*). An oblong shaped hollow receptacle with pointed ends, used in the loom for carrying the weft backwards and forwards through the shed (*q.v.*), so that it may interlace with the warp threads and form woven cloth. The principal woods of which it is constructed are boxwood, cornel, persimmon, and apple-tree. In the hollow part of the shuttle is fixed a tongue or peg, on to which the cop, pirn, or quill, containing the weft is slid. The reciprocating movement of the shuttle is effected by the "picking motion" (*q.v.*) The weft thread from the cop, pirn, or quill is passed through eyes in the shuttle, in order to regulate the tension. *See also* LOOM, SHUTTLING, *and* SLEY.

Shuttle Box (*Weaving*). An enclosure or terminus at each end of the shuttle race, from the one to the other of which the shuttle is ejected and received, and in which the picker or driver works for propelling the shuttle. A bulging steel spring fitted at the side of the box serves to neutralise the force of the shuttle when entering. *See* SHUTTLE.

Shuttle Guard (*Weaving*). A thin wrought iron rod the width of the sley top, and to which it is affixed in order to reduce the chances of a shuttle flying out of shed.

Shuttle Machine, Schiffle (*Lace Manufac.*) That form of Swiss embroidery machine wherein a series of needles and shuttles are employed, constituting it a very speedy machine.

Shuttle Protector (*Weaving*). An attachment to a loom for preventing traps, in case the shuttle fails to reach the shuttle box. Two kinds: (1) Loose reed; (2) Fast reed.

Shuttle Race *or* **Trashboard** (*Weaving*). A long narrow board fixed on the upper part of the sley, and on which the warp threads of the lower part of the shed rest. The shuttle traverses the shuttle race when passing through the shed. The shuttle race should be made of short grained hard wood, well seasoned, so that it will neither split nor warp, and it must have a smooth surface. *See* LOOM.

Shuttling (*Weaving*). The method of controlling the shuttles or bringing the requisite shuttle and kind of yarn into position for the successive sheds in weaving. *See* LOOM.

Si (*Chem.*) The symbol for Silicon (*q.v.*)

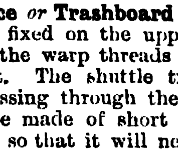
——.(*Music*). The Sol Fa name for B.

Siccative (*Dec.*) *See* DRIERS *and* PATENT DRIERS.

Sicilian (*Textile Manufac.*) A fabric which is similar, as regards materials, to mohair lustre, but thicker weft used, in order to produce a matted appearance.

Sickening (*Mining*). Flouring (*q.v.*)

Side Chains (*Chem.*) When an aliphatic residue enters in any position as a substituent in a ring compound it is called a side chain. Example: Ethyl benzene



here the group CH_2CH_3 is called the side chain.

Side Chisel (*Woodwork*). A chisel with the cutting edge at an angle other than a right angle with the blade. Used in wood turning.

Side Drum (*Music*). *See* MUSICAL INSTRUMENTS, p. 444.

Side Elevation. An external view or drawing of the side of an object.

Side Lever Engine (*Eng.*) An obsolete form of beam engine (*see* STEAM ENGINE), with the beam placed low down, near the base plate. It was one of the earliest forms of marine engine.

Sidenotes (*Typog.*) Notes placed in the margin of a page as distinguished from footnotes. *See* NOTES.

Side Rabbets (*Carp. and Join.*) Planes for planing the right and left hand sides of grooves.

Sidereal Day (*Astron.*) The interval of time between two successive passages of a fixed star over a given meridian.

Sidereal Month (*Astron.*) The time it takes the moon to make her revolution from a given star to the same star again, as seen from the earth's centre.

Sidereal Noon (*Astron.*) *See* SIDEREAL TIME.

Sidereal Time (*Astron.*) The sidereal hour is $\frac{1}{24}$th part of the sidereal day (*q.v.*) The time is reckoned from sidereal noon, *i.e.* the instant when the vernal equinox is on the meridian. It is the hour angle of the vernal equinox or the right ascension of the observer's meridian.

Siderite (*Geol. and Min.*) (1) A synonym for CHALYBITE (*q.v.*) (2) A term sometimes applied to the nodules of clay ironstone commonly met with in connection with the shales of the Carboniferous Rocks.

Siderography (*Engrav.*) Literally, the art of engraving on steel or iron, but more especially a method of engraving effected on soft steel plates, which are subsequently hardened and the design transferred to a soft steel roller, which is in turn hardened and used for printing from.

Siderostat (*Astron.*) A form of instrument composed mainly of a plane reflector and a driving clock, for reflecting the light of any celestial object horizontally in a southern direction. Generally used in conjunction with a telescope mounted horizontally.

Sidestick (*Typog.*) A narrow piece of furniture, straight on one side and tapering on the other. It is placed at the side and at the foot of pages, so that a space is left between it and the chase in which the quoins may be driven with the mallet and shooting stick when locking up.

Side Tank (*Eng.*) A water tank placed along the side of the boiler of a locomotive; used chiefly in small engines such as contractors' locomotives.

Side Tool (*Eng., etc.*) A tool whose end is bent round or so formed that the cutting edge is parallel to the axis of the tool.

Siege (*Glass Manufac.*) The floor or bed of the furnace.

Siemens-Martin Process (*Met.*) *See* IRON *and* SIEMENS PROCESS.

Siemens Process (*Met.*) The production of steel from pig iron by means of an open hearth process in a reverberatory furnace. The pig is mixed with a suitable proportion of scrap steel or malleable iron, melted in the furnace, and spiegel or ferromanganese (*q.v.*) afterwards added. In a modification of this process the pig is fused with iron ores rich in oxide of iron; while in the latest form, termed the SIEMENS-MARTIN PROCESS, both iron ore and scrap iron are used. The furnace is of the regenerative type (*q.v.*), the charge being melted by the combustion of the gases in the chamber of the furnace; by proper regulation of the supply of air, the gases may be caused to exert a reducing or an oxidising effect on the metal, or may be rendered neutral, so as to have no direct chemical effect whatever. Impurities of the pig iron such as phosphorus may be removed in the form of slag by providing a furnace lining of dolomite (*q.v.*), and thus steel may be obtained ready for casting. *See also* METALLURGY.

Sieve. A screen of mesh work composed of various materials and various degrees of fineness (*i.e.* size of opening) according to the particular purpose for which it is required. In assaying, crushed ores, etc., are caused to pass through a sieve of eighty or more meshes to the linear inch.

Sight Feed Lubricator (*Eng.*) A lubricator in which the supply of oil is visible to the eye.

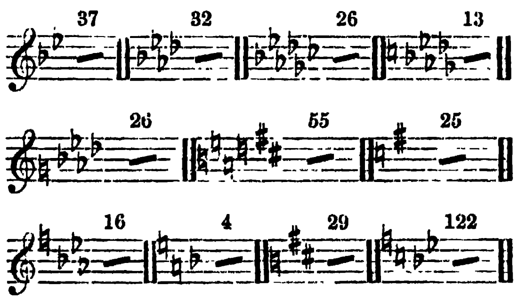
Sight Holes (*Met., etc.*) Openings through which the interior of a furnace can be seen.

Sigillaria. The name given to certain forms of plants found in coal formation; so named from the seal-like markings in their stems. They have no representatives in modern vegetation. Their roots are known as *Stigmaria.*

Signal, Holmes'. *See* HOLMES' SIGNAL.

Signals and Signalling (*Railways*). *See* RAILWAYS.

Signature (*Music*). The signs at the beginning of a musical composition. Signatures are of two kinds, the key and the time. (*See* KEY SIGNATURE *and* TIME SIGNATURE.) When a change of key signature occurs in a composition it is usual to cancel so much of the former signature as is not required. In Beethoven's Sonata in B♭, Op. 106, the following key signatures occur in the fugue for three parts:



—— (*Typog.*) A letter or figure placed in the white line at the foot of the first page of each sheet (or half sheet) of a book, etc., to serve as a guide when the sheets are being folded, and to indicate their order. It also serves to identify a particular sheet.

Signs of the Zodiac (*Astron.*) Signs named after the constellations which occupy the Zodiac, a portion of the heavens extending nine degrees on either side of the ecliptic, in which the sun and major planets perform their annual revolutions.

Silent Feed (*Eng.*) A substitute for a ratchet wheel and pawl for actuating the feeding mechanism of circular saws, etc. A form of friction clutch acts on a plain disc, the clutch gripping the disc during its forward movement and releasing it when drawn back, thus producing an intermittent rotation of the disc which is analogous to that of a ratchet wheel, but free from noise.

Silhouette. (1) A portrait or other drawing in profile, the outline being generally filled in with black; sometimes cut out from the material on which it was sketched. (2) The outline of a solid body, *e.g.* the silhouette of a range of hills: the skyline. (3) A figure cast by a shadow on a wall.

Silica (*Geol.*) Silicon dioxide in one form or another, or in combination as silicic acid with various bases, is the most important constituent in the Earth's crust. *See* SILICATES.

—— (*Min.*) A term used to include the three species Quartz, Tridymite, and Opal; though most frequently it refers to Quartz.

Silica Bricks. Firebricks composed chiefly of silica are often used in the parts of furnaces which are exposed to intense heat, but not in contact with fluxes or molten metal. *See also* BRICKS.

Silicate *or* **Slag Wool.** Slag which has been formed into fine fibres resembling wool by allowing steam to play upon a jet of molten slag; it is a good non-conductor of heat, and is used for covering steam pipes and for similar purposes.

Silicates (*Chem.*) Salts of the various silicic acids. *See* SILICON COMPOUNDS.

—— (*Geol.*) Native compounds of silicic acid with various bases. Most of them are formed in connection with either eruptive rocks or else with such metamorphic rocks as gneiss (*q.v.*) Having regard first to their mode of origin, the silicates may be grouped under three primary categories: (1) Those which are the original constituents of eruptive rocks. (2) The silicates of secondary origin which are developed in situ as a consequence of metamorphic action. (3) Silicates arising from the solution of certain minerals in one place and their redeposition, usually in the hydrated condition, in another. High temperatures and pressures prevail during the formation of the two former, and low pressures and temperatures during the formation of the last. The silicates which are of chief importance from a geological point of view are: (*a*) The Felspars and Felspathoids, which are silicates of alumina and of various alkalies or alkaline earths. Muscovite and the Micas allied to it are closely related to these. (*b*) The ferromagnesian silicates, which comprise the Amphiboles, which include Hornblende; the Pyroxenes, of which Augite is a good representative; Biotite and the Micas allied to it; and Olivine, with which may be included several closely allied species. (*c*) The Zeolites and the minerals usually classed with them. *See also* PRECIOUS STONES (III.)

Siliceous Deposits (*Geol.*) Three classes of siliceous deposits occur: (1) Those which arise directly from the tests of radiolaria or the spicules of sponges left on the ocean floor. (2) Siliceous deposits from geysers and hot springs. (3) Secondary deposits of silica, usually chalcedonic in character, due to the solution of diffused siliceous particles, such as sponge spicules, in stratified rocks, and its redeposition as chert or flint. To these might be added a fourth, which arises from the decomposition of silicates, and its redeposition at lower levels.

Siliceous Iron (*Met.*) Silica in iron produces effects analogous to those of carbon; the iron is brittle and unreliable if the silica exceeds a very small amount.

Siliceous Sinter (*Geol.*) Spongy deposits of opaline silica, deposited, largely through the action of bacteria, on the surface of the earth around the mouth of certain hot springs. These deposits, being closely associated with geysers, have been termed GEYSERITE.

Silicon (*Chem.*) Si. Atomic weight, 28·4. An element belonging to the same group as carbon in the periodic system; it can be obtained, like carbon, in an amorphous and in a crystalline form. AMORPHOUS SILICON is a maroon-coloured powder; melts only in the electric furnace; insoluble in acids, except a mixture of hydrofluoric and nitric; soluble in alkalis evolving hydrogen and forming silicates; burns in oxygen, forming silica. It is obtained by heating pure silica with magnesium powder and magnesium oxide in a fireclay crucible, and purifying the product by washing with hydrochloric acid to remove magnesium oxide, and with hydrofluoric and sulphuric acids successively and repeatedly to remove silica, and finally with water. Another form of amorphous silicon is obtained when sparks from an induction coil are made to pass either through liquid or gaseous silicon hexahydride; it reduces solutions of copper sulphate, mercuric chloride, and potassium permanganate. CRYSTALLISED SILICON: Silicon crystallises in six-sided plates or in needles; the crystallised form is more stable towards reagents than the amorphous form. It is obtained by heating silica with excess of aluminium in the electric furnace, when the liberated silicon dissolves in the metal and crystallises out on cooling; the product must be treated successively with hydrochloric and hydrofluoric acids to remove aluminium and silica.

—— (*Min.*) This element does not occur native, but in combination as the oxide, silica, it is very abundant, the anhydrous form being Quartz; the hydrous, Opal. A mixture of Quartz and Opal constitutes Chalcedony. There is a rare form of the anhydride, called Tridymite, which occurs in minute hexagonal plates. Silicon combined as silicates is very abundant; the number of different silicates known in mineralogy is over two hundred.

Silicon Compounds (*Chem.*) HYDRIDES: Silicon tetrahydride, SiH_4, is a colourless gas; boils at about $-116°$; decomposed into its elements when heated; easily takes fire in air on warming or even on sudden reduction of pressure; decomposed by caustic potash solution, $SiH_4 + 2KOH + H_2O = K_2SiO_3 + 4H_2$. It is obtained mixed with hydrogen and the hexahydride, and spontaneously inflammable by the action of hydrochloric acid on a heated mixture of magnesium and silica (magnesium silicide),

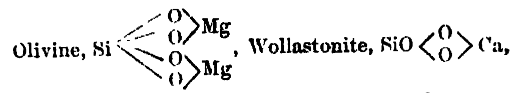
$$SiMg_2 + 4HCl = SiH_4 + 2MgCl_2.$$

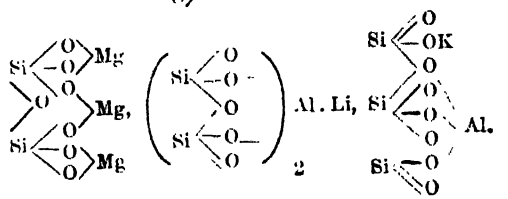
It is obtained pure by the action of sodium on ethyl orthosilicoformate,

$$4H.Si(OC_2H_5)_3 = SiH_4 + 3Si(OC_2H_5)_4.$$

SILICON HEXAHYDRIDE, Si_2H_6, is a colourless liquid; boils at 52°; it is spontaneously inflammable in air; behaves as a reducing agent. It is obtained along with the tetrahydride and hydrogen as above; the product of the reaction is cooled by liquid air when the hydrides solidify; or melting, the tetrahydride escapes. SILICIDES: Carbon silicide, CSi (CARBORUNDUM), is a colourless crystalline solid; very infusible; nearly as hard as diamond. It is made on a large scale by heating together for a long time, in a specially constructed electric furnace, glass sand, coke, sawdust, and a little salt. It is used

for grinding and boring, in steel making, and as a refractory material in the construction of high temperature furnaces. The metallic silicides are made by heating the metal and amorphous silicon together, or by heating the oxide with silica and carbon, in both cases in the electric furnace. They are hard crystalline solids, not easily attacked by reagents; but when the metal decomposes water at the ordinary temperature the silicide does so too. The silicides of the alkalis and alkaline earths yield hydrides of silicon when acted on by hydrochloric acid; *e.g.* calcium silicide is said to give silicon acetylene, Si_2H_2, with dilute hydrochloric acid; lithium silicide gives the hexahydride, and magnesium silicide acts as above. SILICON FLUORIDE, SiF_4, is a colourless gas; solidifies at $-97°$, and volatilises without melting; fumes strongly in air. It is decomposed by water to silicic and hydrofluosilicic acids. *See* HYDROFLUOSILICIC ACID. It is formed by the action of fluorine on silicon or silica, and by the action of hydrofluoric acid on silica; usually it is prepared by heating a mixture of powdered glass and fluorspar with concentrated sulphuric acid. SILICON CHLORIDE, $SiCl_4$, is a colourless liquid; boils at 59°; it fumes in air, and is decomposed by water, $SiCl_4 + 4H_2O = H_4SiO_4 + 4HCl$. It is prepared by passing dry chlorine over a very strongly heated mixture of carbon and silica. Silicon trichloride, Si_2Cl_6, boils at 146°, and begins to dissociate at 350°; the dissociation is complete at 800°; quickly heated to above 1,000°, the substance is said to be again stable. It is obtained by heating silicon in the vapour of the tetrachloride. SILICON CHLOROFORM, $SiHCl_3$, is a colourless fuming liquid; boils at 34°; very inflammable; with alcohol it forms ethyl orthosilicoformate, $H . Si(OC_2H_5)_3$. It is obtained by heating silica with powdered magnesium to obtain silicon and heating the product in a current of hydrochloric acid gas: the liquid resulting is purified by fractional distillation. SILICON OXIDE or SILICA, SiO_2, is met with in amorphous, vitreous, and crystalline forms; it is only fusible at the temperature of the oxy-hydrogen flame; it is very stable towards reagents, among acids only hydrofluoric attacks it (*see under the* FLUORIDE); alkalis attack it, forming silicates, $SiO_2 + 2KOH = K_2SiO_3 + H_2O$; a few other actions are described above. When melted it can be drawn out into threads so fine that they make excellent suspensions in physical instruments; it can also be blown like glass, and quartz vessels are much used as tubes, flasks, thermometers, because they can be heated and rapidly cooled without fear of cracking, and are less acted on than glass by many substances. Pure amorphous silica may be made from sand or any insoluble silicate by fusion in a platinum crucible with six times its weight of fusion mixture to form sodium and potassium silicates: the fused mass is extracted with water, filtered, acidified with hydrochloric acid, evaporated to dryness, and heated. There now remains a mixture of silica and sodium and potassium chlorides; the latter are extracted with water, and the silica is dried. When silica is fused it solidifies in the vitreous form. Silica occurs naturally in very many forms. Sand is often nearly pure silica; other examples are: *Crystalline:* Quartz, Amethyst, Tridymite. *Semi-crystalline:* Chalcedony, Carnelian, Agate. *Amorphous:* Flint, Chert, Touchstone. *Hydrated:* Opal, Hydrophane, Kieselgühr. SILICIC ACIDS: When a solution of sodium silicate, obtained by fusing pure silica with sodium carbonate and extracting the fused mass with water, is decomposed by hydrochloric acid, a gelatinous precipitate results if the solution is strong, but a clear liquid if the solution is weak; in the latter case, if the clear liquid be dialysed, a colloidal solution is obtained. A gelatinous precipitate is also obtained when silicon tetrafluoride is passed into water. These products have very feeble acid properties, and are compounds of silica with water. Products of the composition H_4SiO_4 and H_2SiO_3, corresponding to orthosilicic acid and metasilicic acid, have been obtained from these compounds of silica and water; but they are so unstable, changing in composition with small changes in temperature and even on exposure to air, that it is doubtful if as yet these acids have been prepared. SILICATES may be regarded as derived from orthosilicic acid and its anhydride, metasilicic acid, or from di-, tri-, etc., silicic acids, and their anhydrides. Examples:





Serpentine. Petalite—from the anhydride of disilicic acid. Orthoclase — from anhydride of trisilicic acid.

An alternative way of writing formulæ for silicates is to represent them as compounds of silica with the various metallic oxides, *e.g.* on this plan olivine would be written $2MgO . SiO_2$; orthoclase, $K_2O . Al_2O_3 . 6SiO_2$. Related elements can often in part replace each other in these silicates; in these cases the mutually replaceable elements are written in brackets. Many examples of important silicates with their formulæ written on the latter plan are given in the article on PRECIOUS STONES (*q.v.*) Many organic compounds of silicon are known.

Silk, Artificial. *See* CELLULOSE *and* WOOD PULP.

Silk Spinning and Weaving. Silk is a fine soft thread produced by the larva of the Bombycid moth, of which there are several species. The one generally cultivated, and from which the world's silk crop is chiefly derived, is the *Bombyx Mori*, or common silkworm. The eggs are about the size of a grain of mustard seed, of a bluish grey colour, and the larvæ or worms are hatched at the time of year when their natural food, the leaves of the mulberry tree, are making their appearance. About a quarter of an inch in length when hatched, the worm attains its full size, nearly three inches, in six weeks or rather more, according to the temperature in which it is reared. During this time it changes its skin four times, at each of which periods it becomes lethargic and refuses to eat. When prepared to spin, the worm selects a convenient nook or angle, and beginning at first with loose supporting threads, it gradually winds around itself an increasingly dense oval shaped ball of white or golden yellow coloured silk called the cocoon. Completing the process in three to five days, it passes into the chrysalis stage, in which it remains from fifteen to thirty days, according to climate. The chrysalis is then trans-

formed into the moth, which emerges from the cocoon by first moistening and then pushing aside the surrounding filaments. In this form it exists for a few days only, during which time the female deposits its eggs, varying from two hundred to five hundred in number. Although the moth in forcing its way through the cocoon does not eat or sever the threads, it injures the silk to some extent, and renders it difficult to reel. To prevent this the cocoons (with the exception of those intended for breeding purposes, which are carefully selected and placed aside) are subjected to treatment by heat, either in the form of steam or hot air, which destroys the vitality of the chrysalis. REELING: To reel the silk the cocoons, having been first stripped of the outward floss, are placed in a copper trough containing soft water heated to a degree sufficient to soften the natural gum and enable the thread to unwind freely. The reelable thread of the cocoons having been found, four or more ends, according to the size required, are taken and placed together, and uniting by means of the natural gum, form one thread. This passes through a succession of guide eyes, and returning to its first direction, is crossed and intertwisted on itself, causing a pressure which condenses the filaments into a compact, round, smooth thread, which passes on to a revolving reel. Great care is required to rapidly replace a filament should one break or run out, this being done not by a process of tying, but by simply attaching it to the thread in motion, to which it adheres by reason of its wet, gummy condition. Crude methods and carelessness in reeling are responsible for the inferiority of the bulk of Asiatic as compared with European silks; but the "FILATURE" SILKS of China and Japan, so called when reeled by European machinery and methods, cannot be excelled for beauty and evenness. THROWING: The reeled thread, termed "RAW SILK," is received by the throwster in large hanks. It is first divided into smaller hanks, then sorted into grades of size and wound on bobbins. It is again rewound on other bobbins, the thread passing through a cleaner, a narrow opening between two blades sufficiently large to allow the passage of the thread, but stopping its progress when lumps or nibs present themselves. If for ORGANZINE, the bobbins, which are made to revolve, are placed in an upright position in a spinning machine, the thread is conducted through an eye, wound round an upright wire two or three times to give tension, and in passing on to another bobbin, receives usually about fifteen twists or turns to the inch. These bobbins then pass to the doubling frame, are again placed in an upright position, but do not revolve, the threads being taken from them by means of an eyelet at the end of a revolving wire, usually two, but sometimes three, threads passing together on to one bobbin. The bobbins containing the double or trebled thread are then placed in the throwing machine and wound off into skeins, either for ordinary or for Grant reel, the thread receiving a certain number of turns per inch, according to the fabric for which the silk is intended—about eleven turns if for satin faced fabrics, more if for crêpe, gauze, umbrella silks, or other fabrics where the warp threads are subjected to much friction in the process of weaving. For TRAM the singles get no twist; the reeled thread is wound and then doubled, receiving only a slight spin. After throwing, the skeins are weighed, and the length of the skein being known, the size of silk is determined by the weight of each skein according to length. The term "silk spinning" is also used in connection with the utilisation of the waste silk made in reeling, winding, and throwing. Fully 30 per cent. of the produce of the silkworm can only be treated by this method. The waste silk is combed into short lengths or drafts from 2 to 6 in. in length. The ends are laid carefully over each other and, passing through a series of combs and over a drum, are drawn out into a lap of about 2 yards in length. These lengths are again laid continuously over each other, and passed over rollers and through combs, being drawn out eventually into a sliver or tape of several hundred yards. After this treatment the spinner is able to pass the silk on to a bobbin by the roving process, as generally employed in cotton spinning. The subsequent processes correspond very nearly to those used in cotton or wool manufacture. WEAVING: With the exception of a few fabrics woven in the grey or gum state, silk is dyed in the skein before weaving. It loses about 25 per cent. of its weight if dyed "soft" or "bright," by the extraction of the natural gum in boiling off, and about 12½ per cent. if dyed "souple." There is no loss if dyed "hard." It is then wound on bobbins, the organzine being warped into the required length and count, and afterwards spread upon the cane or warp roll by a process called "beaming." In low counts warped by power, the warping mill is dispensed with, the silk passing direct from the creel on to a drum from which it is beamed. The warp is then placed in the loom, and the threads "entered" or passed one by one through the loop or eye of the shaft in plain, or of the maille in figured harness, and afterwards drawn in sections through the interstitial spaces of the reed. In the case of a harness through which a cane has just been finished, the new warp is joined thread by thread by a process of "twisting" to about a yard length of the previous warp left in it, termed a "thrum." The art of weaving in its most primitive state consisted of picking up the warp threads with the fingers and interlacing them with the weft, but as science advanced the idea was conceived of raising a section of the warp by means of a heddle, thus obtaining a shed or opening for the weft to pass through, and it is at least probable that the weaving of linen and woollen cloths by the latter method was practised by the ancients ages before they had any knowledge of the possibility of spinning a weavable thread from the product of the silkworm. The plain HAND LOOM, which still retains much of its original simplicity, is a wooden structure consisting of four posts so placed as to form a rectangle, and framed together at top with beams. It is usually about 6 ft. in height, 6 ft. 6 in. in length, and 4 ft. 6 in. in width for cloth 36 in. wide or less. At one end, supported in clamps attached to the posts, the warp roll is placed; at the opposite end is the cloth beam or breast roll on which the woven silk is wound, the harness is placed about 15 in. from the breast roll and suspended from levers (termed TUMBLERS or TIPLERS) at the top of the loom, and attached by cords to other levers beneath, called long and short lames. Between the harness and the breast roll is the batten carrying the reed. The shed is obtained by the weaver pressing his feet alternately on treadles which, acting upon the harness, raise certain heddles whilst depressing others; simultaneously with such action he pushes back the batten with one hand, throwing the shuttle through the shed with the other, the return action of the batten causing the reed to beat up the weft to the required number of picks per inch. In many narrow works, and always where the fabric exceeds

36 in. in width, the fly batten is used. In figured weaving, a mounture or figured harness replaces or supplements the plain harness. The working of this was at one time a slow, laborious method, requiring in addition to the weaver who raised the ground harness and threw the shuttle a lad called a "draw boy," who worked a machine at the side of the loom and obtained the shed for the figure by drawing in their required order of succession lashes attached to the mounture cords. The arranging of the lashes and cords for a particular pattern was a long and expensive operation frequently occupying many months before weaving could begin. A great revolution in figure weaving was effected by J. M. Jacquard, of Lyons, who in 1801 patented a machine which, placed on the loom and attached to the mounture, enabled the weaver to obtain the shed for figure and ground together, thus dispensing entirely with the services of the draw boy. Its action is controlled by perforated cards, laced together in an endless band, which pass over a cylinder and act in succession on the points of a set of horizontal wires called needles, connected with which are perpendicular hooks attached to the neck cords of mounture. Where the cards are perforated, the needles stand forward, enabling metal blades called the griffe, when raised by weaver depressing the treadles, to catch corresponding hooks, thus drawing up the warp threads in mounture and creating the shed. Simultaneously with the shedding motion the pressure of the card on the needles is removed, allowing the latter where driven back by the blank spaces in the cards to be returned to their position by means of small brass springs placed behind them. With the return of the griffe a fresh card is brought to bear on the face of the needles. The Jacquard for silk weaving usually contains 408 or 612 hooks, needles, and springs, the number of possible perforations in the cards corresponding. The POWER LOOM, the invention of which dates back to 1785, was not adapted to any extent to the weaving of silken fabrics until many years later, it being thought that silk, owing to its fine delicate texture, could only be successfully and profitably dealt with by the hand loom weaver. Constant improvements, however, in the various parts of the mechanism, particularly of the shedding and picking motions, in the manipulation of the warp, the adaptation of improved Jacquards and swivel battens for figured fabrics, have rendered the up-to-date power loom capable of weaving the most beautiful and elaborately figured, as well as the simplest, plain silks to perfection, and with the exception of a few exceedingly rich qualities, of which only short lengths are required it has superseded the hand loom. The mechanism of the power loom comprises various makes and patents, many of them equally good, but the motions they control are essentially the same as in the hand loom, *viz.* (1) the creation of the shed by the raising and depressing of certain heddles in plain weaving, or by the raising of certain hooks of Jacquard in figured weaving; (2) the propelling of the shuttle carrying the weft through the shed; (3) the beating up of the weft by means of the reed carried in the batten; and (4) the taking up of the cloth when woven. The construction of the power loom is more compact than the hand loom, the warp roll is placed much nearer the harness, no long porry being required for picking and cleaning the silk, this having been done before the warp is placed in the loom; the batten instead of swinging from the loom top is attached to and works on a pivot at the base of the loom, the shuttle race and reed being thus at the top of the batten. The shuttle is much larger and heavier than used in hand loom, giving steadiness when running at a hundred and fifty or more picks a minute, and by accommodating a large pirn or bobbin, enables the loom to run for a longer period without stopping for renewal of supply of weft. A delicately adjusted weft fork, placed between the shuttle box and edge of cloth, feels for the weft thread at each pick as it enters the shuttle box, stopping the loom should it break or run out. The SHED is obtained by the following motions: The tappet or eccentric for the simplest form of plain cloth, the dobbie for other plain cloths such as twills, satins, checks, etc., the Jacquard for figured weaving. The cloth when woven is wound on cloth roll by a set of change wheels of different sizes, which by careful adjustment take up the cloth and regulate the number of picks required, a compensating appliance acting on batten keeping the cloth of an even thickness when weft is irregular. Silk fabrics, with the exception of those having a pile surface, such as velvet or terry, are woven face downwards.—F. W.

Sill (*Build.*) (1) The lowest horizontal member of a window, door frame, partition, etc. (2) The stone at the bottom of a window or a door opening.

—— (*Civil Eng.*) The horizontal member forming the floor, or lowest margin of the opening, of dock gates, etc.

—— (*Geol.*) A term now generally applied to an intrusive sheet of eruptive rock, such, for example, as the Whin Sill of the North of England. It differs from a Laccolite (*q.v.*) in the fact that a Sill does not occupy the position of a bedding plane.

—— (*Mining*). (1) The floor of a gallery or passage. (2) A flat mass, ledge, or surface; in particular, a flat mass of hard rock.

Sillimanite (*Min.*) *See* ANDALUSITE.

Silo. *See* ENSILAGE.

Silurian System (*Geol.*) A name applied to the great group of marine sediments which lie between the Devonian Rock on the one hand and those of Ordovician Age on the other. As now classified in accordance with the nature of their fossil contents, they consist of (1) the Downtonian Rocks, below which are (2) the Salopians, which in their turn overlie the Valentian Rocks. In Westmorland their aggregate thickness is fully 12,000 feet.

Silver (*Chem.*) Ag. Atomic weight, 107·9. A white metal; crystallises in regular forms, such as the cube and octahedron; melts at 961°; boils at 2,050°; very malleable and ductile, capable of taking high polish; the best conductor of heat and electricity. Very thin films transmit blue light. Melted silver dissolves oxygen; 1 volume silver dissolves about 20 volumes oxygen; on solidifying it gives up the dissolved oxygen, and this gives rise to the "spitting" of silver, the escaping oxygen raising the solidified surface of the metal into fantastic shapes. Silver is not oxidised in air at the ordinary temperature nor on heating, but on heating in oxygen at 300° under a pressure of 15 atmospheres it is oxidised to the extent of 50 per cent.; it unites with the halogens directly; sulphuretted hydrogen and aqueous solutions of the alkaline sulphides convert it into sulphide,

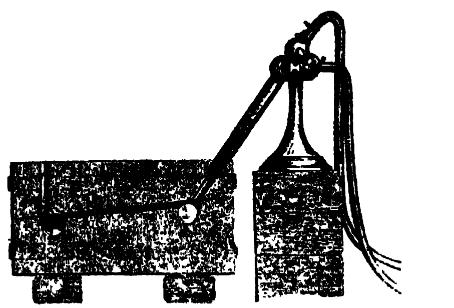
$$2Ag + Na_2S + 2H_2O = Ag_2S + 2NaOH + H_2.$$

Hydrochloric acid has no action, but hydrobromic and especially hydriodic acid dissolve it with liberation of hydrogen, probably owing to the

solubility of silver bromide and iodide in the respective acids. Hot strong sulphuric acid gives silver sulphate and sulphur dioxide. Nitric acid dissolves it readily. *See* NITRIC ACID. Allotropic forms of silver are said to be produced when silver solutions are precipitated by various reducing agents, *e.g.* when silver nitrate is precipitated with ammonia iron citrate. These precipitates vary in colour from blue black to red. When dilute silver nitrate is reduced by hydrazine hydrate, a green form is obtained in solution. By passing the electric arc between silver poles under water a reddish brown liquid is formed. (*See* ENZYMES.) None of these forms of silver has been obtained pure, and the "solutions" are probably "suspensions" only. Silver sometimes occurs native; more commonly as Argentite (*q.v.*), Pyrargyrite (*q.v.*), Polybarite (*q.v.*), Horn Silver (*q.v.*) Many different processes are employed to extract silver from its ores: (1) MEXICAN AMALGAMATION PROCESS. The ore consists chiefly of silver and silver sulphide. The process is worked where steam and water power are not available. The wetted ore is ground between blocks of porphyry turned by mules; mixed on a paved floor (patio) with common salt by the trampling of mules; mercury and a substance known as magistral (copper pyrites roasted so as to make copper sulphate) are added, and these things well trampled in; more mercury is added, and the trampling continued; but the charge (torta) is also turned from time to time with shovels; the trampling goes on till the requisite amount of mercury is amalgamated. This may take some days. The mass is now washed with water in large vats provided by stirrers worked by mules The amalgam is filtered through canvas, pressed, and distilled, when mercury passes over and silver is left behind. A recent explanation of the changes is that cuprous chloride is formed by double decomposition between cupric sulphate and salt and reduction of the cupric chloride by mercury; the cuprous chloride then acts as an oxygen carrier.

$Cu_2Cl_2 + 4O + Hg + Ag_2S = Cu_2Cl_2 + HgSO_4 + 2Ag.$

This explanation is offered because silver chloride is difficult to work by this process, and it is never found in the torta, and the author (Ortega) uses copper hypochlorite in place of cuprous chloride, which is much quicker in its action. (2) Where steam power is available the WASHOE AMALGAMATION PROCESS is commonly used. In this the ore is first well crushed with water, then ground to a fine pulp in iron pans with water and mercury, common salt and copper sulphate being added if desirable; also, if the ore contains sulphide, sodium is added to the mercury to prevent formation of mercuric sulphide; the pulp is washed by agitating it with water, this allowing the amalgam to settle, while earthy impurities are washed away; excess of mercury is removed by pressing the amalgam in canvas bags, and then the amalgam is distilled in iron retorts, the silver remaining behind in the retort. The crude silver is melted and stirred with iron rods, so that oxidisable metals are removed—some oxides, such as those of antimony and bismuth, volatilising, while others, such as copper and lead, form a scum on the silver which can be skimmed off. A considerable amount of silver is obtained from burnt pyrites. (*See* COPPER.) From the precipitated iodide the silver is easily obtained by reduction with zinc and hydrochloric acid. Galena usually contains silver, and from the argentiferous lead obtained from galena the silver is extracted by Parkes' process. (*See* LEAD.) COMMERCIAL SILVER is always impure. To obtain CHEMICALLY PURE SILVER many processes are available. Stas, in his atomic weight determinations, employed half a dozen distinct methods, and also distilled silver. The first pure silver he had was prepared by reducing a 1 per cent. solution of silver nitrate by allowing finely divided phosphorus to stand in it; the metal, after standing some time in excess of a silver nitrate solution and being digested with aqueous ammonia, was fused with borax and nitre; it was quite pure. Another method which he used on a large scale, and which gave metal of "extraordinary purity," was to dissolve silver in boiling dilute nitric acid, evaporate to dryness, and melt. On cooling, the nitrate was dissolved in ammoniacal water and allowed to stand, then filtered and diluted till it contained not more than 2 per cent. of silver; then a solution of normal ammonium sulphite (prepared by passing sulphur dioxide into ammonia) was added in quantity such that on warming a portion of the mixture no blue colour remained, and the whole allowed to stand forty-eight hours in a well stoppered vessel; this precipitated one-third of the silver, and the rest is precipitated on heating at 60° to 70°; the precipitate was washed with ammoniacal water till the washings neither turned blue on standing in air nor gave a precipitate with barium chloride; the metal was then left standing a day or two under concentrated ammonia, and finally washed with pure water. To get it in bar form it was melted in an unglazed porcelain crucible with 5 per cent. of its weight of burnt borax, to which 10 per cent. of sodium nitrate had been added. Stas distilled considerable quantities of his pure silver in the arrangement shown in the figure. The block is of burnt white marble held together with iron bands, and is in two pieces, as shown by the sloping line; it is 25 to 30 cm. long and 10 cm. wide, and total height 15 cm.; the right hand hole admits the jet of



an air coal-gas blowpipe to the roughly spherical cavity which serves as retort; the opening connecting retort to receiver is 0·5 cm. high and as wide as the diameter of the retort (3 cm.); the receiver communicates with a vertical opening for escape of uncondensed vapour. The silver distils over in 10 to 15 minutes, and the retort, examined by a lens, shows no trace of a residue. PURE SILVER is not used for any ordinary purposes on account of its softness. The silver used for ORNAMENTAL ARTICLES and for the coinage is alloyed with copper; the hardest alloy contains 4 parts of silver to 1 part of copper. STANDARD SILVER is the silver used for coinage, and it consists of 925 parts of silver to 75 parts of copper. The FINENESS of any other silver is expressed in terms of standard silver by stating the number of pennyweights per pound troy of copper by which it exceeds or falls short of

standard silver; thus 240 dwt. (1 lb. troy) of standard silver contain 18 dwt. copper, and the hard alloy mentioned above (4 parts silver to 1 part copper) contains in 240 dwt. 48 dwt. of copper, so their alloy would be referred to as "worse 30 dwt." "OXIDISED SILVER" is silver which has been superficially coated with silver sulphide by dipping it in potassium sulphide solution. Besides its use in making silver articles and coins, much silver is used in ELECTROPLATING (*q.v.*) and in making mirrors. For SILVERING GLASS many recipes are available. A simple one is: Dissolve 8 grams of Rochelle salt in 3·84 litres of water; boil, and while rapidly boiling add a solution of 10 grams silver nitrate in 80 cc. water; allow to cool and then filter. Now dissolve 10 grams of silver nitrate in 80 cc. water, add ammonia till the precipitate of silver oxide is barely all dissolved, make up to 960 cc. Care being taken that the glass to be silvered is scrupulously clean, it is put in a sufficient quantity of a mixture of equal volumes of each of the two solutions at a temperature of about 20° to 21°. The world's production of silver in 1903 amounted to about 5,800 tons, and by far the greatest part of it was extracted in Mexico and the United States. W. H. H.

Silver (*Min.*) This element occurs native in octahedral crystals belonging to the cubic system. More often it is in filiform masses of silver white colour when fresh, but often tarnished to a black, green or yellow colour. The mineral is sectile, flexible, and ductile. It usually contains traces of copper, gold, platinum, etc. It has been found in Cornwall; more abundantly at Kongsberg in Norway, in Saxony, Bohemia, Hungary, France, Siberia, and in quantity in Central and South America. The element also exists in many other minerals, the chief of which are Argentite, Stephanite, Pyrargyrite, Proustite, Horn Silver, Polybasite, and Freieslebenite (*q.v.*)

Silver Amalgam (*Min.*) *See* AMALGAM.

Silver Compounds (*Chem.*) SILVER OXIDE, Ag_2O, a brownish-black powder; begins to decompose at 250°, and is completely decomposed at 300°; slightly soluble in water (6·5 grams in 100,000 cc. water at 20°), this solution having an alkaline reaction. When moist it reacts as an alkali (AgOH), precipitating hydroxides from many salt solutions and replacing halogens in many organic compounds by hydroxyl groups; *e.g.* tetramethylammonium iodide with moist silver oxide gives tetramethylammonium hydroxide:– $N(CH_3)_4I$ gives $N(CH_3)_4OH$. It dissolves readily in ammonia, and the solution contains the powerful base $Ag(NH_3)_2OH$, which is ionised to $Ag(NH_3)_2{}^{I}$ and $(OH)^{I}$. This solution, on standing exposed to air, deposits the black explosive fulminating silver NAg_3. Silver oxide is prepared by precipitating a solution of silver nitrate with a solution of caustic potash, filtering, washing, and drying the product at 60° to 80°. When a solution of silver nitrate is electrolysed, black crystals are deposited on the anode; these appear to be a compound of a higher oxide of silver with silver nitrate, and have been called silver "peroxynitrate"—probable formula $2Ag_3O_4 . AgNO_3$. SILVER CHLORIDE, AgCl, a white solid; melts at 450°; volatile at a white heat, giving vapour density 80 at 1700°; very slightly soluble in water, 100 cc. solution contain ·000153 gram at 20°; more soluble in hydrochloric acid (1 in 200 of the concentrated acid); it is very soluble in ammonia, potassium cyanide, and sodium thiosulphate solutions, forming soluble double compounds—*viz.* $2AgCl3NH_3$ (also formed by passing ammonia gas over dry silver chloride), $NaAgS_2O_3$, $KAg(CN)_2$. Silver chloride is blackened on exposure to light under ordinary conditions, but not when exposed in dry oxygen or in a vacuum; the blackening is prevented by chlorine water and by ferric chloride solution—substances which can give up chlorine. The explanations offered are (1) that an oxychloride is formed, (2) that a subchloride, Ag_2Cl, is formed. If either of these explanations is correct, it is strange that compounds of these formulæ cannot be prepared artificially. Silver chloride is reduced to the metal by hydrogen, (*a*) when heated in hydrogen—a reversible reaction; (*b*) when in contact with zinc and a dilute acid, such as sulphuric or hydrochloric. It is completely converted into bromide by digesting it with a solution of potassium bromide, and into iodide by potassium iodide. Silver chloride can be prepared by passing chlorine over heated metallic silver, or by precipitating a solution of silver nitrate by hydrochloric acid or a soluble chloride. SILVER BROMIDE, AgBr, a white or yellow solid, according as it is obtained by precipitation of excess of silver nitrate by potassium bromide or by adding excess of the latter to silver nitrate; melts at 429°; nearly insoluble in water; 100 cc. solution contain ·0000084 gram at 20°; soluble in hydrobromic acid, from which it can be crystallised; soluble in strong ammonia; decomposed by chlorine; converted into iodide by digesting with potassium iodide solution. This salt is largely used in preparing photographic plates, owing to the extreme sensitiveness of silver bromide to the action of light. What the action of light is does not appear to be known. SILVER IODIDE, AgI, is a pale yellow solid; melts at 530°; its behaviour on heating is abnormal, as it contracts on heating to 70°, and expands on cooling again, probably owing to a change of form; when pure it is not acted on by light; very slightly soluble in water; 100 cc. solution contain ·000053 grams at 20°; slightly soluble in ammonia; soluble in hydriodic acid and in strong potassium iodide, forming the compounds $HAgI_2$ and $HAgI_3$. It is easily decomposed by chlorine; it is reduced by zinc and dilute hydrochloric or sulphuric acid to the metal. Silver iodide is obtained by precipitating silver nitrate solution by potassium iodide solution; by dissolving silver in hydriodic acid, and from either the bromide or chloride by digesting them with solution of potassium iodide. SILVER NITRATE, $AgNO_3$ (also called LUNAR CAUSTIC); white rhombic plates; often met with cast in sticks; melts at 198°; very soluble in water; 100 cc. water dissolve 227·3 grams at 19·5°. Decomposes when strongly heated, leaving behind metallic silver and giving off nitrogen peroxide, oxygen, and nitrogen; with ammonia in excess it forms the compound $AgNO_32NH_3$, which crystallises out on allowing the solution to evaporate, and exists in solution ionised into $Ag(NH_3)_2{}^{I}$ and $NO_3{}^{I}$ (*cf.* SILVER OXIDE); dry silver nitrate absorbs ammonia gas and forms the solid $AgNO_33NH_3$, with evolution of much heat. It is rapidly reduced to metallic silver (black) by organic matter, especially in presence of light. Hydrogen slowly reduces it to the metallic state. Silver nitrate is made by dissolving silver in nitric acid, evaporating to dryness, fusing, and recrystallising from water. It is employed in preparing other silver salts; in medicine for cauterising; as a hair dye. SILVER NITRITE, $AgNO_2$; a white crystalline powder; sparingly soluble in water; used in the preparation of pure alkaline nitrites and of fatty nitro-compounds. It is prepared by mixing warm solutions of silver nitrate and

potassium or sodium nitrite. SILVER SULPHATE. Ag_2SO_4, is a white crystalline solid, sparingly soluble in water: 100 cc. water dissolve ·58 gram at 18°; it is made by dissolving silver in hot concentrated sulphuric acid; occasionally used as a reagent. SILVER CYANIDE, AgCN, a white solid, very slightly soluble in water; 100 cc. solution contain ·000022 gram at 20°; decomposed on heating into silver and cyanogen; heated with sulphur, it forms the sulphocyanate AgCNS; it is soluble in ammonia and in potassium cyanide solutions, forming the compounds $AgCN.NH_3$ and $KAg(CN)_2$: the latter is a white crystalline solid, which is much used in the electrolytic deposition of silver. Silver cyanide unites with alkyl iodides when these are heated together in sealed tubes with a little ether, and the product yields alkyl isocyanide when distilled with potassium cyanide: $C_2H_5I + 2C_2AgCN = C_2H_5Ag(CN)_2 + AgI$ $C_2H_5Ag(CN)_2 + KCN = C_2H_5NC + KAg(CN)_2$. Silver cyanide is made by adding potassium cyanide solution to a solution of silver nitrate. Silver forms salts with all organic acids, and the great majority of these organic silver salts are insoluble in water. On being heated in air they decompose, leaving a residue of silver. In virtue of this property they are used to determine the molecular weights of organic acids, for it is obvious that if the basicity of the acid is known to be n, and a grams of the normal silver salt on heating leave behind b grams of silver, then

$$\frac{\text{Molecular weight of silver salt}}{108\,n} = \frac{a}{b}.$$

$$\therefore \text{Molecular weight of acid} = \left(\frac{108a}{b} - 107\right)n.$$

Silver Glance (*Min.*) *See* ARGENTITE.

Silver Grain (*Carp., etc.*) The grain or markings in timber due to the medullary rays (*q.v.*) Oak cut so as to display the silver grain to advantage is termed WAINSCOT OAK.

Silvering. Coating an object with silver either by chemical deposition or by electrolytic methods. *See* ELECTROPLATING.

Silver Lead Ore (*Min.*) Galena containing a sufficient quantity of silver to make it profitable to extract the silver. The amount of silver in the ore varies from mere traces up to 3 per cent. When silver was at a higher price, an ore containing three ounces of silver to the ton paid for extraction by the Pattinson process.

Silver Leaf (*Dec.*) When used by sign writers and decorators consists of pure silver reduced to sheets; applied in the same manner as gold leaf. It must be protected by a coating of lacquer or varnish, or it will turn black. Aluminium leaf, which does not change colour, is now usually employed instead of silver.

Silverplating. *See* ELECTROPLATING.

Simile (*Music*). In the same manner. When a figure is to be repeated, instead of writing the passage again, simili marks are put thus // or ·/· (*cf.* "And lo!" and "And suddenly," in Handel's *Messiah*).

Simoon (*Meteorol.*) A term applied to the hot suffocating winds laden with dust and sand which are peculiar to the sandy deserts of Africa and Western Asia.

Simple Harmonic Motion (*Phys.*) *See* HARMONIC MOTION.

Simple Machines. The term used in theoretical mechanics to denote the Levers, Pulleys, Wheel and Axle, Inclined Plane, and Screw. They are often called the MECHANICAL POWERS, but the term is not a good one, and should be avoided.

Simple Microscope (*Light*). A single lens used for producing a magnified virtual image of an object placed close to the lens: a magnifying glass is therefore a simple microscope.

Simple Pendulum (*Phys.*) *See* PENDULUM.

Simpson's Rule. A useful rule for the measurement of the areas of irregular plane figures. The area is divided into strips by parallel and equidistant lines or ordinates. The length of each of these ordinates and their distance apart is measured; then the total area is the product of the ***distance apart × half the sum of the first and last ordinates, + the sum of the remaining ordinates.***

Sin. SINE: *see* TRIGONOMETRICAL RATIOS.

Sinapine (*Chem.*) *See* MUSTARD OILS.

Sine (*Math.*) *See* TRIGONOMETRICAL RATIOS.

Sine Curve. *See* SINES, CURVE OF.

Sine Galvanometer (*Elect.*) *See* GALVANOMETERS.

Sines, Curve of (*Math.*) A curve showing the ratio between an angle of given value and its sine. An example is given under Harmonic Motion (*q.v.*)

Singeing (*Textile Manufac.*) The process of passing the thread during the final spinning or doubling through jetted flames of gas. If applied to the yarn, also termed "gassing." Fabrics in which mohair yarn is used for the weft are singed over hot rollers. *See* GASSING.

Singing Flame (*Sound*). A jet of hydrogen and certain other gases when burnt under the mouth of a tube open at both ends will often set up a loud note.

Single Acting Engine (*Eng.*) An engine in which the impulse is given on one side of the piston only; they include nearly all the ordinary forms of gas, oil, and petrol engines, and a number of high speed steam engines, such as those of Willans, Brotherhood, and Mather and Platt. *Cf.* STEAM ENGINES.

Single Acting Piston (*Eng.*) The piston of a single acting engine; it is commonly made in the form of a short cylinder closed at one end and having the connecting rod hinged to a gudgeon pin within it. This forms what is sometimes termed a TRUNK PISTON. *See* GAS ENGINE *and* PETROL ENGINE.

Single Belt (*Eng.*) A driving belt composed of one thickness of leather.

Single Cylinder Machine (*Paper Manufac.*) A paper machine provided with one very large drying cylinder instead of the usual twenty or thirty.

Single Ended Boiler (*Eng.*) A ship's boiler having a grate at one end only.

Single Fished Joint (*Eng.*) A joint with one fishplate (*q.v.*)

Single Floor (*Carp. and Join.*) A floor consisting of one set of joists, to which the floor boarding and ceiling are fixed. *See* FLOORS.

Single Flue Boiler (*Eng.*) A CORNISH BOILER. *See* BOILERS.

Single Fluid Hypothesis (*Elect.*) *See* ELECTRICITY.

Single Geared Lathe (*Eng.*) A lathe without back gear (*q.v.*)

Single Phase Current (*Elect.*) An ALTERNATING CURRENT (*q.v.*) of the ordinary kind.

Single Riveting (*Eng.*) A lap joint is single riveted when there is one row of rivets only; a butt joint when there is one row on each side of the joint.

Singles (*Eng.*) Sheet iron intended for tinning.

Sinister (*Her.*) The sinister or left hand side of a shield. It must be remembered that this refers to a shield, as it was held to protect the body; to the spectator from the front the sinister side is on his right hand.

Sinking (*Build.*) A recess; any part below the general surface of an object.

Sinking Pump (*Civil Eng.*) A pump which can be lowered into a shaft or other deep excavation until it is sufficiently near the bottom to draw up water into its barrel.

Sinks (*Sanitation*). By a model bye-law of the Local Government Board the waste pipe from every sink must discharge in the open air over a channel leading to a trapped gully at least 18 in. distant. The waste pipe should be provided with a siphon trap fitted with a screw cap, which can be removed for the purpose of cleansing the trap. *See* SIPHON TRAP; TRAP; *and* SEAL.

Sinople (*Her.*) Vert. *See* HERALDRY.

Sinter *or* **Geyserite** (*Min.*) *See* SILICEOUS SINTER.

Sinusoidal. Having the form of a sine curve (*q.v.*)

Siphon. A bent tube with arms of unequal length, used for drawing a liquid out of a vessel. The shorter arm dips into the liquid, while the other arm overhangs the containing vessel in such a way that its end lies below the level of the liquid. If the tube be first filled with the liquid, which is prevented from escaping while the tube is being placed in position, the liquid will commence to flow through the siphon, and will continue to flow so long as the shorter arm dips into, and the outer end is below the level of the liquid in the vessel. The siphon may be placed in position when empty, and started by drawing the liquid up into the tube by suction applied to the longer limb.

Siphon Barometer (*Meteorol.*) A form of barometer the tube of which is in the form of a siphon. There are three main classes of barometers, SIPHON, CISTERN, and ANEROID. *See* BAROMETER.

Siphon Recorder (*Elect. Eng.*) A form of telegraphic recording instrument in which the symbols are produced on a moving strip of paper by a fine jet of ink, flowing from a light glass tube bent so as to form a siphon. One arm of the latter dips into a reservoir of ink, while the other end can be moved backward or forward through a small distance by the action of the transmitted current.

Siphon Trap (*Sanitation*). This consists of a pipe curved somewhat like the letter S, the lower bend being intended to retain sufficient water to reach above the level of the upper side of its curve. The water so retarded forms a "water seal," and prevents the entry of sewer and other gases from the drains. In the case of sink discharge pipes, a screw cap or CLEANING EYE is fitted at the lowest point of the bend, and can be removed for cleansing the trap. *See* SEAL *and* TRAP.

Siren (*Sound*). A piece of apparatus for investigating the pitch of a note or the relation of pitch to frequency. A rotating plate is pierced with holes bored at equal distances along the circumference of a circle on the plate. On causing an air jet to impinge on the row of holes, a note is produced whose frequency is proportional to the number of holes which pass the jet in one second. The number of revolutions of the plate is registered by some form of counting mechanism, and hence the total number of vibrations per second which corresponds to the particular note observed can be determined. Very large sirens are commonly used in factories and on steamships to emit a loud note as a signal or warning, *i.e.* to serve as foghorns.

Sirocco (*Meteorol.*) A hot moist wind, receiving its heat from the Sahara and its moisture from its passage northward over the Mediterranean. Met with in Sicily, South Italy, and adjoining districts.

Sisal Hemp (*Botany*). A fibre largely used in ropemaking. It is obtained by maceration of the leaves of the American aloe, *Agave rigida* (order, *Amaryllidaceæ*).

Sistrum (*Archæol.*) An instrument of the character of a rattle, especially associated with the worship of the Egyptian goddess Isis. It consisted of metal rods fitting loosely in an oval-shaped metal frame, the ends of the rods being bent up to prevent them from slipping out.

Sites (*Hygiene*). The following considerations should, if possible, be taken into account in the choice of a building site: (1) The nature of the Soil (*q.v.*) (2) The aspect, as regards wind, light, air. (3) The surroundings, as, for example, the neighbourhood of trees or hills. The distance of the ground water from the surface is an important factor in the healthiness of a site; it should never be less than 10 ft., and, if possible, at least 15 ft. or 20 ft. from the ground level. As regards aspect, other things being equal, an east or south-east aspect is to be preferred, so as to secure the maximum amount of sunlight both on the front and back of the house. Valleys lying in the direction of the prevailing winds are healthier than those lying in other directions. The neighbourhood of trees is desirable, provided they do not obstruct the light and air. Rising ground facilitates the natural drainage both of the surface and of the subsoil. *See* SITE AND STRUCTURAL ARRANGEMENT OF HOUSES *under* SANITATION.

Sitting (*Art*). The period during which a person sits for a portrait, or during which a model poses. The uninterrupted period during which an artist works.

Six-Part Vaulting (*Architect.*) *See* SEXPARTITE VAULT.

Six's Thermometer (*Heat*). *See* MAXIMUM AND MINIMUM THERMOMETER.

Sixteenmo (*Print.*) A sheet printed so as to form 16 leaves (32 pages) when folded. Abbreviation, 16mo.

Sixth (*Music*). The interval of two notes alphabetically six letters apart, as D to B. *See* INTERVAL.

Sixty-four-mo (*Print.*) A sheet which when printed is folded so as to form 64 leaves (128 pages) of a book, the size of each leaf being about $2\frac{1}{4}$ by $3\frac{1}{2}$ in. A book of this size.

Size. Glue or other gelatinous material which has been allowed to absorb a considerable quantity of water, thus forming a soft and homogeneous jelly.

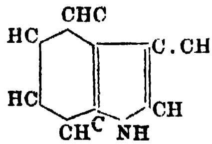
—— (*Bind.*) (1) A preparation consisting of a thin solution of glue or paste wash applied to bindings previous to finishing and gilding. (2) A

solution of gum tragacanth or gum dragon used for floating the colours in marbling (*q.v.*)

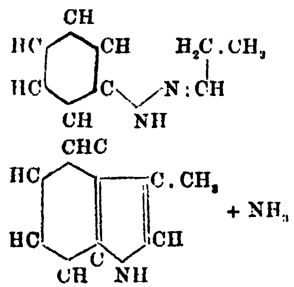
Sizing. The process of treating a surface or a substance with a suitable size (*q.v.*)

—— (*Textile Manufac.*) The application of a glutinous liquid to the warp yarn for the purpose of increasing the adhesiveness of the fibres and strengthening the threads for weaving. In cotton manufacture the warp yarns are passed through a size mixture composed of flour, tallow, soap, etc. *See* SLASHER SIZING *and* LINEN MANUFACTURE.

Skatole (*Chem.*)



(Scatole: β-methylindole). White shining plates; melts at 95°; boils at 266° (755 mm.); it has a strong fæcal odour, and occurs in fæces; it is sparingly soluble in cold water, much more soluble in hot water; soluble in alcohol, ether, light petroleum. It gives the pine-shaving reaction (*see* PYRROLE) but only when the shaving is dipped in a hot alcohol solution, and then put into concentrated hydrochloric acid. It gives a picrate (red needles). It gives a nitroso compound with nitrous acid. Skatole always occurs in fæces; it is sometimes present in urine combined with sulphuric acid. Skatole is formed in the putrefaction of proteids, *e.g.* egg-albumin, and when proteids are fused with caustic potash. It is also formed from indigo by reducing it with tin and hydrochloric acid, and distilling the product with zinc dust (when prepared in this way it does not smell of fæces). It is prepared synthetically by heating the phenyl hydrazone of propionic aldehyde with zinc chloride (its own weight): the reaction begins without the aid of heat, but toward the end it is heated to 180° for a minute.



The product is distilled in steam, and the distillate extracted with ether. Skatole is used to some extent in making artificial perfumes.

Skean, Skein (*Arms*). A double-edged dagger or sword peculiar to the ancient Irish race.

Skean-dhu (*Arms*). The knife or dagger worn by Scottish Highlanders in the stocking.

Skeleton. Framework which constitutes the chief supporting parts of a structure, *e.g.* a series of iron bars on which a plaster cast is built up.

—— (*Zool.*) The framework supporting the body of an animal; it consists of (1) connective tissue; (2) cartilage; (3) bone. The internal structure usually termed the skeleton is distinguished in zoology as the ENDOSKELETON; in addition to this, or in place of it (in the case of invertebrates) there may also be an EXOSKELETON, a hard external structure serving to support the body.

Skeleton Drums (*Paper Manufac.*) Light cylindrical frames constructed of wood, used in drying "tub sized" papers.

Skeleton Form (*Typog.*) A form (*q.v.*) of a light or open character, consisting either of rules to form boundaries and columns for table matter or of odd lines to be printed in a second colour.

Skeleton Frame (*Join.*) Wooden framing of any description, without panels.

Skeleton Girder (*Eng.*) A LATTICE or openwork girder (*q.v.*)

Skeleton Pattern (*Foundry*). A pattern whos form follows the main outlines of the casting, the remainder of the mould being completed by hand.

Sketch (*Art*). A preliminary study or design.

Skew. Oblique; at an angle; twisted to one side.

Skew Arch. *See* ARCH.

Skew Back (*Build.*) The bed of an arch, at the springing.

Skew Bevel Wheels (*Eng.*) Bevel wheels whose axes do not intersect.

Skewers (*Foundry*). Wires used to support loose parts of a pattern which have to be detached when the pattern is withdrawn from the mould; the skewers take the place of dowells.

Skidda *or* **Skiddaw Slates** (*Geol.*) A series of ancient marine argillaceous sediments, now somewhat roughly cleaved, which are typically developed on Skidda, near Keswick, in the Lake District. They were originally shales (*q.v.*) with some flagstone and grit, and here and there some thin bands of submarine volcanic tuff. But they have since undergone a considerable amount of disturbance, and have locally been much metamorphosed by the action of bosses of granite which have risen through them, chiefly in Devonian times. Their original extent is unknown, but it must have been considerable, as they form most of the Isle of Man, and must extend from there at least as far as Eastern Westmorland. They may underlie a large area in the south of Scotland, and it is possible that they may extend far towards the borders of Wales. Their exact thickness is not known, but the aggregate thickness visible cannot well be much less than 5,000 ft. The highest beds of the Skidda Slate known for certain occur near Milburn, where they yield graptolites and other fossils of Lower Llandeilo types. Near Keswick other graptolites have been found, which prove that the part of the Skidda Slates occurring near there are of Arenig age. Below these horizons occurs an unknown thickness of older parts of the Skidda Slates, part of which must be of Tremadoc age, and the remainder may be of the same age as the Lingula Flags of Wales. As clements in the scenery of the Lake District the Skidda Slates take an important part, as they form such mountains as Skidda and Saddleback; but, as a rule, they weather into much smoother surfaces than the volcanic rocks which overlie them to the south; and the contrast where the two rocks occur side by side is very striking. The Skidda Slates rarely afford slates which are of much economic importance, though they are employed to a considerable extent as rough building material. Some of the Skidda Slate which has been indurated and partly recrystallised by the intrusion of granite masses—as, for example, the one

to the north of Threlkeld—gives forth a clear sonorous ring when struck, and has often been used for a rude kind of harmonicon. The "musical stones" well known to visitors to the Lake District are of this nature. Some of the more arenaceous bands which occur close to the granite bosses have been thermo-metamorphosed into hornfels; while a few of the argillaceous bands have been dynamo-metamorphosed into true phyllites. The Skidda Slates are succeeded southward of Keswick by a thick pile of andesitic tuffs, highly cleaved, and largely used for slates. These are the well-known "Green Slates." Some bands of andesitic and other lavas occur with them. The whole pile seems to lie unconformably upon the Skidda Slates. It is these rocks which form most of the picturesque scenery of the Lake District, from Ambleside to near Keswick Their position in the geological scale is not certain, and there is nothing to show that they are not of Devonian age. J. G. G.

Skidding. The slipping of a wheel, as distinguished from rolling.

Skimmer (*Foundry, etc.*) An implement used to prevent the scum on the surface of molten metal from entering the mould while the metal is being run in from a ladle.

Skimming Gate *or* **Chamber** (*Foundry*). A cavity. circular in plan, forming an enlargement of the gate (*q.v.*) through which metal enters a mould. The metal flows into the cavity by an opening on one side, and a rotating motion is set up, which carries the pure metal towards the circumference, and the lighter dross and scoriæ towards the centre of the chamber. The iron escapes by means of a gate, and runs straight into the mould. Castings made in this manner are said to be "run with a skimming gate" or "run with a ball."

Skin (*Eng.*) The hard outer layer of a casting, etc., owing to the cooling of the surface having occurred more rapidly than that of the interior. In castings the skin is also apt to contain siliceous matter derived from the mould.

—— (*Zool.*) (1) *See* EPIDERMIS *and* CUTICLE. (2) The name generally given to the pelt of a small animal, the term "hide" being applied to the skin of a large animal.

Skin Effect (*Elect.*) The tendency of any current which is varying in amount to flow in the outer layers of a conductor. On the application of an electromotive force to a conductor, the current will diffuse inwards in a manner similar to that in which heat would diffuse if the surface of the metal were heated. The effect is negligible in small conductors unless the frequency, or the rate of variation in the value of the current, is very great.

Skip. A bucket or similar receptacle for holding loose material which is hoisted by cranes. A basket or box used for raising material from mines.

Skip Pass (*Textiles*). *See* ENTERING.

Skippet (*Archæol.*) A round box in which one of the large seals formerly attached to documents was enclosed for protection.

Skiver (*Leather Manufac.*) The thin grain split of the sheepskin, used for thin bindings, purse leather, and for pocket books. *See* SHEEP *and* CHAMOIS LEATHER.

Skraup's Reaction *or* **Synthesis.** *See* QUINOLINE.

Sky Glow (*Meteorol.*) Accompanies the rising and setting sun, and is due to the diffraction and reflection of light by the minute dust particles in the atmosphere. Sometimes extraordinarily brilliant after volcanic eruptions, as in 1883 and 1902.

Slab (*Build., etc.*) (1) The outside piece of a log when sawn into boards or planks; it is rough on one side. (2) A thin, flat, regularly shaped piece of material, *e.g.* marble.

Slabbing (*Carp.*) Cutting off the rough sides of a balk of timber.

Slack. Small coal used in forges, certain kinds of furnaces, and as a source of carbon in various metallurgical operations.

Slacking Down (*Eng.*) DAMPING DOWN (*q.v.*)

Slack Side (*Eng.*) The loose side of a belt, *i.e.* the portion running away from the pulley which is transmitting the power.

Slag (*Met.*) The masses of fused and often vitreous or glassy silicates, resulting from a great number of metallurgical operations. They contain the major part of the non-metallic materials of the ores, combined with others derived from the fluxes employed, and a certain residuum of the original metal or other constituent. Slags have a number of uses, *e.g.* as BALLAST, HARD CORE, etc. Certain kinds can be made into bricks, others supply a very fair HYDRAULIC CEMENT (*q.v.*) Blast furnace slag supplies SLAG WOOL or SILICATE WOOL (*q.v.*), and basic slag from the Bessemer process is a valuable phosphatic manure. Other slags rich in oxides are useful in smelting operations. *See* COPPER.

Slagging (*Met.*) The withdrawal of the slag from a furnace.

Slag Wool. Sometimes called SILICATE COTTON. It consists of very thin filaments of blast furnace slag. It is used as a non-conducting covering and as an abrasive. By blowing a jet of steam into a stream of molten slag a shower of slag pellets is formed, which in their flight spin out fine threads or filaments of slag. A current of air sucks away the finest portions in the form of slag wool, leaving the pellets and other coarser particles. The wool is further graded according to its fineness.

Slaked Lime (*Build.*) Quicklime to which water has been added. *See also* CALCIUM COMPOUNDS.

Slake Trough (*Eng.*) A trough used in the forge to contain cold water for damping the fire, cooling hot iron, etc.

Slancio, Con (*Music*). With impetuosity.

Slargando (*Music*). Enlarging in tone and decreasing in speed.

Slash (*Cost*). One of a series of narrow slits or openings made in fashionable outer garments for the purpose of showing an under germent, or the openings were filled in with fancy material termed slashings. Slashed costumes were much in vogue during the Tudor period.

Slasher (*Cotton Manufac.*) The Slasher sizing machine. The term is applied also to the attendant. *See* SLASHER SIZING.

Slasher Sizing *or* **Taping** (*Cotton Manufac.*) A popular and economical method of preparing grey cotton warps for the loom. The yarn from the back beams is passed through a size mixture, and after drying is run on to a weaver's beam at the front of the machine. There are several makes: (1) Drum cylinder. (2) Cavity cylinder. (3) Hot air chamber. (4) Steam chests.

Slate (*Geol.*) A term frequently applied to any rock that will split into slabs thin enough to be used for roofing purposes. Geologists, however, restrict the use of the term to rocks which split along planes of cleavage. In Cumberland some of the best slates are cleaved volcanic tuffs; but slates, as a rule, are argillaceous rocks. *See also* SKIDDAW SLATES.

Slates, Roofing (*Build.*) Roofing slates are sorted and sold in various sizes, as follows:—

Doubles . . .	13 in. × 6 in.
Ladies	16 in. × 8 in.
Viscountesses . .	18 in. × 9 in.
Countesses . . .	20 in. × 10 in.
Duchesses . . .	24 in. × 12 in.
Princesses . . .	24 in. × 14 in.
Imperials . . .	30 in. × 24 in.
Queens	36 in. × 24 in.

The sizes most in use are the Duchess and Countess.

Slating Battens (*Build.*) Wood fillets nailed to the common rafters; the slates or tiles forming the roof are fixed to the battens.

Slaughterhouses. *See* ABATTOIRS.

Slay. *See* SLEY.

Sleaker. *See* SLEEKERS.

Sledge *or* **Sledge Hammer** (*Eng., etc.*) A heavy hammer swung by both hands. *See* HAMMERS.

Sleekers *or* **Smoothers** (*Foundry*). Tools used by moulders for smoothing or SLEEKING the interior of a mould after the pattern has been withdrawn. They are made in various shapes to suit different varieties of work.

Sleeking *or* **Smoothing** (*Foundry*). The smoothing of a mould. *See* SLEEKERS.

Sleepers (*Civil Eng.*) Supports laid on the ground or on ballast (*q.v.*) to carry the lines for a railway. They are usually of fir, soaked in creosote; but in countries where wood is destroyed by ants, etc., iron sleepers are used. *See* RAILWAYS.

Sleeper Wall (*Build.*) A dwarf wall to give intermediate support to ground floor joists.

Sleet (*Meteorol.*) Rain mixed with snow or hail. Formed from snowflakes falling through a stratum at a temperature of 32° F. or higher. Falls chiefly in winter and spring.

Sleeve (*Eng.*) A general name for a fitting in the form of a hollow cylinder or tube. Used in a variety of machinery.

Sleeve Piece (*Plumb., etc.*) *See* BRASS THIMBLE.

Sleeve Screw (*Eng.*) A screw cut on the surface of a hollow shaft or sleeve.

Sleeve Wheel (*Eng.*) A wheel whose hub or boss is in the form of a sleeve or hollow cylinder.

Slentando (*Music*). Gradually slackening the speed.

Slewing (*Eng.*) Turning round through an angle. Applied usually to pieces of mechanism such as a crane.

Slewing Gear (*Eng.*) The mechanism by which a crane is turned or slewed about a vertical axis in order to pick up or deposit goods in various positions.

Sley *or* **Slay** (*Lace Manufac.*) A band or strip either of metal drilled with the requisite number of holes or wire woven into a network similar to canvas. Its use is to enable the threads that will eventually compose the lace to be arranged in an orderly and systematic manner, and to keep them apart in the interspace between leaving the warp or beams and entering the guide bars by which the threads are acted upon.

Sley *or* **Slay** (*Weaving*). The going part of a loom, constructed of wood. It carries the shuttle boxes, reed, and trashboard or shuttle race, and assists in beating up the weft. (*See* REED.) The shuttle boxes are fixed at each end of the sley, with the reed between, the body of the sley being bolted to vertical iron supports or sley swords working on a centre stud or shaft. An eccentric motion is imparted to the sley by means of a connecting rod working from the loom crank, whereby more time is allowed for its backward movement (when the shuttle passes through the shed) than for its forward movement (when it beats up the weft). Also termed LAY, LATHE, BATTEN (*q.v.*) *See also* LOOM for illustration.

Sleying (*Weaving*). The operation of drawing the warp threads (after they have been passed through the healds or harness eyes) through the dents or splits of the reed, preparatory to fixing the reed in the sley or batten of the loom for the final operation of weaving. *See* LOOM *and* SET.

Sley Sword (*Weaving*). *See* SLEY.

Slice (*Eng.*) A stoker's tool with a thin blade, used for breaking up a caked fire or clinkers.

—— (*Print.*) The name for (*a*) a flat bladed knife used for lifting ink from the can to the ductor or ink slab. (*b*) The false bottom of a galley made to slide out.

Slickensides (*Geol.*) Pairs of striated surfaces produced on hard rocks by grinding against each other when the rocks have been undergoing disturbance. They very commonly accompany faults (*q.v.*) Slickensides somewhat resemble glacial markings; but in the former the striæ generally terminate abruptly, and minor roughnesses are always present, in which respect they differ sensibly from the smooth furrows and ridges produced by glacial action.

Slicker (*Leather Manufac.*) A tool used in leather manufacture for setting out smoothly and stretching leather.

—— (*Moulding*). A SLEEKER (*q.v.*)

Slide (*Eng.*) A general term for a piece of mechanism which possesses a fully controlled rectilinear motion.

—— (*Music*). (1) An ornament. *See* ORNAMENTS. (2) Part of the mechanism of trumpets and trombones which enables the tube to be lengthened. *See* TROMBONE, *p.* 437. (3) Part of the mechanism of the organ, also called slider. *See p.* 439.

Slide Bars (*Eng.*) The bars which cause the crosshead on the end of a piston rod to move in a straight line. *See* STEAM ENGINE.

Slide Blocks (*Eng.*) The blocks on the ends of the crosshead of an engine, which move or slide along the slide bars.

Slide Lathe (*Eng.*) A lathe with a SLIDE REST (*q.v.*)

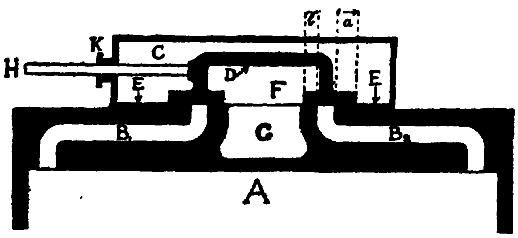
Slide Rest (*Eng.*) A device which holds and also controls the direction of motion of a turning tool. In self-acting lathes it consists of a base or SADDLE sliding on the lathe bed, and moved either by the leading screw or by the back shaft, so as to travel at a definite rate along the bed. Above the saddle is fixed a CROSS SLIDE, above which is the

TOOL HOLDER. The latter can be caused to move in a direction at right angles to the bed of the lathe by means of a screw in the cross slide. This screw is either turned by hand or can be actuated by mechanism from the back shaft. In other lathes the saddle has no self-acting motion, but is fixed to the bed in any required position by a bolt, in the same manner as the back poppet, and carries two slides, one giving a motion parallel to the bed, the other at right angles. In many cases the lower of these slides can be turned round through an angle, so that the tool moves in a direction making an angle with the axis of the lathe, enabling a conical or tapering object to be turned. *See* LATHE.

Slide Rest Lathe (*Eng.*) A lathe with a SLIDE REST (*q.v.*)

Slide Rule (*Eng., etc.*) A very simple and efficient calculator, capable of performing multiplication, division, evolution, and involution of numbers. It consists essentially of two similar scales having graduations proportional to the logarithms of successive numbers, usually from 0 to 100. It can be successfully used by any one without knowledge of logarithms, and its use effects an immense saving of time in engineering and other calculations. The small size, 10 in. long, gives results which are correct to about 1 part in 500; but elaborate instruments, *e.g.* Fuller's Special Slide Rule, give results correct to 1 in 10,000. As a general rule, however, it is most convenient to use tables of logarithms when accuracy greater than that attainable by the 10 in. rule is required.

Slide Valve (*Eng.*) In most forms of the steam engine the admission of the steam to the cylinder is controlled by a valve which is moved backward and forward by the valve gear, over the openings or PORTS leading into the cylinder. A typical form is



shown in the diagram. A is the cylinder; B_1, B_2 are the STEAM PORTS or passages through which steam enters from a VALVE CHEST C, to which it is led from the boiler. Over these ports the valve D slides along a plane surface or SEAT E. The hollow space F within the valve communicates with an opening G, termed the EXHAUST PORT, from which a pipe, termed the EXHAUST PIPE, leads to the condenser, or in the case of a non-condensing engine, to the open air. The valve is moved by the VALVE ROD H, passing through a steam-tight STUFFING BOX K. If the valve be moved to the right the port B_1 is uncovered and steam can enter the left-hand end of the cylinder, driving the piston to the right. The valve then commences to return towards the left, and covers B_1 again, thus cutting off the steam, which commences its expansion in the cylinder. At the end of the stroke the valve has moved so far to the left that B_1 is in communication with the space F, and the steam now escapes through the exhaust port G. The same processes occur (in reversed order) at the other end of the cylinder. It will be seen that the edges of the valve project beyond the ports; this projection is termed the LAP. The distance *a* which the valve projects beyond the steam port when in its middle position is termed the OUTSIDE LAP, and the distance *b* the INSIDE LAP. The effect of the former is to close the steam ports before the end of a stroke, thus rendering expansive working possible; the latter prevents the escape of steam until the valve has moved from the middle position through a distance equal to the amount of the inside lap. If the valve had no lap, steam could enter one of the steam ports whenever the valve was displaced rom the middle position, and would continue to enter until the valve returned to this position, *i.e.* during the whole of each stroke. There would then be no expansion of the steam, and the indicator diagram (*q.v.*) would be approximately a rectangle. The eccentric (*q.v.*) would be so adjusted that its radius—that is, the line joining the centre of the eccentric sheave to the centre of the crank shaft—was at right angles to the crank shaft. The existence of the outside lap requires the eccentric radius to be set in advance of this position, in order to open the valve at the beginning of a stroke; a further small advance is also made in order to open the valve just before the stroke begins. The amount which the valve is actually open at the commencement of a stroke is termed the LEAD. The angle between the crank and the eccentric radius thus exceeds a right angle by an amount termed the ANGULAR ADVANCE, which depends on the lap and lead. The correct adjustment of the positions of the valve and eccentric is termed SETTING the valve.

Slide Valve Spindle (*Eng.*) The VALVE ROD. *See* SLIDE VALVE.

Slide Wire (*Elect.*) The straight wire which furnishes the two variable resistances in a Wheatstone Bridge (*q.v.*) of the straight form known as a Slide Wire Bridge.

Sliding (*Eng.*) (1) In general, any smooth linear motion. (2) In particular, the movement of a tool parallel to the bed of a lathe by means of the SLIDE REST (*q.v.*)

Sliding Blocks (*Eng.*) SLIDE BLOCKS (*q.v.*)

Sliding Fit (*Eng.*) Two parts which fit together easily, yet without the least amount of shake or play, are said to make a sliding fit.

Sliding Friction. The friction (*q.v.*) between two surfaces which are in motion over or relatively to each other.

Slimes (*Met.*) Finely crushed residues from the milling and crushing of ores. *See also* AMALGAMATION PROCESSES *and* METALLURGY.

Sling (*Eng.*) A general term applied to various devices by which an object is suspended, *e.g.* a suitably bent bar or a loop, by which a heavy weight is attached to a crane.

Slip (*Build.*) A thin liquid, or, more correctly, some solid suspended in a liquid, *e.g.* a mixture of clay and water.

—— (*Civil Eng.*) (1) An inclined plane upon which a vessel is supported while being built, or upon which a vessel is placed for repairs. A contrivance for hauling vessels out of the water for repairs. (2) Falling in of the sides of a cutting or embankment is prevented by attention to three points: (*a*) Keeping the slope at a sufficiently low angle; (*b*) Efficient drainage; (*c*) Protection of the surface from weather, chiefly by encouraging the growth of grass and other vegetation.

Slip (*Eng., etc.*) (1) Relative motion of two objects. (2) A thin oil stone for giving a finish to the edge of cutting tools.

—— (*Geol. and Mining*). A miners' term for the displacement accompanying a fault (*q.v.*): also for the amount of that displacement.

—— (*Pot.*) Clay containing so much water that it is of about the consistency of thick cream.

Slip Dock (*Civil Eng.*) A dock which can be emptied and which contains a slip (*q.v.*)

Slip in Motors, etc. (*Elect. Eng.*) The ratio of the frequencies of rotor and stator currents. If ω is the angular velocity of the rotating field, and ω_1 that of the rotor, then the Slip $= \frac{\omega - \omega_1}{\omega}$.

Slip Kiln (*Pot.*) A shallow tank under which are flues. It is used for the conversion of slip into clay by evaporation.

Slip of a Screw Propeller (*Eng.*) The difference between the actual velocity of a steamship and that which it would have if the screw were turning in a fixed nut which exactly fitted the blades. The slip is obviously due to the yielding nature of the water.

Slipper *or* **Slipper Block** (*Eng.*) A SLIDE BLOCK (*q.v.*)

Slipper Brake (*Eng.*) A brake for vehicles running on rails. It consists of blocks attached to the frame of the vehicle in such a way that they can be thrust down on the rails, thus checking the motion.

Slippery Iron (*Met.*) Cast iron containing 2 or 3 per cent. of manganese; so called because it is capable of acquiring a very smooth surface, suitable where there is much friction, as in the cylinders of engines, etc.

Slip Proof (*Typog.*) A proof pulled when the type or matter is on the galley, *i.e.* before it is made up into pages.

Slips (*Bind.*) The ends of the bands or cords to which a book is sewn. They eventually serve to attach the book to the millboards, into which they are laced and then hammered. *See* BANDS, BOARDS, BOOKBINDING, *and* LACING IN.

Slip Winding (*Lace Manufac.*) The operation of winding cotton or other material from skeins or hanks on to wood or similar bobbins.

Slip Winding Engine (*Lace Manufac.*) A machine for accomplishing the foregoing operation.

Slit (*Met.*) The technical term for the nail rods used by nail makers, because they are made by passing bars through a slitting mill (*q.v.*) which slits them up into rods.

—— (*Phys.*) A narrow opening used in spectroscopes and other pieces of apparatus in order to obtain a narrow beam of light. The slit is usually formed in a diaphragm furnished with a device by which the width of the opening can be adjusted.

Slitless Spectroscope (*Astron.*) When a spectroscope is used without a collimator, that is, when parallel light rays are under investigation, the instrument is termed a slitless spectroscope. Another name is an objective prism spectroscope, or, when used for photography, a prismatic camera.

Slitting File (*Eng.*) A file with a thin blade like a knife, used in filing a thin groove.

Slitting Mill (*Met.*) A pair of rolls fitted with steel collars or discs which intermesh and act on the bar iron, as it is fed between the rolls, like a rotary shearing machine.

Sliver (*Textile Manufac.*) A collection of cotton, flax, or woollen fibres which have been formed into a tape-like strand for the purpose of being subsequently spun into yarn. *See* ROVE, SLUBBING *and* LINEN MANUFACTURE.

Slop Closets (*Sanitation*). Closets which are flushed by means of the slops or refuse liquids of the household, instead of by clean water. There are two kinds, *viz.* those in which the waste water runs directly into the basin and those in which, in order to obtain a better flush, the waste water is collected in a siphon, cistern, or tipper, and then discharged in a sudden flush; these latter are known as "automatic slop closets." A number of these closets can be placed on one drain, a single trap, placed at the bottom of the manhole, serving for the whole—a ventilation shaft being provided at the upper end. Slop closets are now placed in many working class houses in the Midlands.

Slope Tile. A glazed earthenware receptacle in which draughtsmen's colours are mixed ready for use. It contains a number of shallow pits with sloping bottoms.

Slop Sink (*Sanitation*). Usually a large "short-hopper" china basin with a siphon trap below, furnished with a grid to prevent obstruction in the pipes. The trap should be connected with the soil pipe, the basin provided with a flushing rim, and flushed from a water waste preventer. A slop sink should only be used when it is undesirable to discharge slops from bedrooms or hospital wards through the water closet.

Slot (*Eng.*) (1) A general term for a long narrow recess or aperture, particularly one in which a pin or block fits. (2) A continuous narrow opening between the rails of a cable-tramway, by which the grip on the car effects connection with the travelling cable.

Slot Drilling (*Eng.*) Cutting a slot by means of a kind of revolving drill. The drill has no vertical motion, the feed being entirely due to the motion of the piece of metal, which is moved along by a table.

Slot Link (*Eng.*) The slotted link used in the LINK MOTION (*q.v.*)

Slotted Armature (*Elect. Eng.*) An armature in which the conductors lie in slots or grooves instead of on the outer surface.

Slotting (*Eng.*) Cutting a SLOT (*q.v.*)

Slotting Machine (*Eng.*) A modification of a shaping machine (*q.v.*), in which the tool moves in a vertical line. It is used for cutting Key ways (*q.v.*) and in various other operations.

Slotting Tools (*Eng.*) The tools used in the SLOTTING MACHINE (*q.v.*) They resemble those used in metal-turning lathes, so far as the form of the cutting edge is concerned; but they are often bent to enable the tool to reach the work, as they move along a straight line which is the direct prolongation of their own axis.

Slubbing (*Cotton Spinning, etc.*) The process in spinning in which the strand or sliver (*q.v.*) is not only further drawn out to a smaller diameter, but also first receives a slight twist as it is wound on to a bobbin by means of a "flyer" affixed to a spindle. The resultant drawn and partially twisted sliver is also termed a Slubbing. *Cf.* ROVE, ROVING.

Slubs (*Cotton Spinning*). Thick places in cotton yarns caused by faulty preparation in the spinning processes.

Sludge (*Eng., etc.*) The muddy sediment deposited in a boiler.

—— (*Sanitation*). The solid and semi-solid portions of sewage, separated from the liquid portions by settling or precipitation.

Sludge Cock (*Eng.*) A wide tap at the bottom of a boiler through which much of the sediment can be washed out by a brisk supply of water from a hose.

Sluice (*Civil Eng., Mining, etc.*) (1) A channel constructed for the purpose of conveying water in a given direction; the water so conveyed. *Cf.* FLUME. (2) A sliding gate or other contrivance in a lock gate or dock gate for effecting or controlling the passage of water. (3) In mining, a trough with an arrangement at the bottom for holding quicksilver, in order to separate the gold from the placer dirt when carried through by a current of water.

Slur (*Music*). A curved line placed over or under two or more notes of different pitch to show that they are to be performed *legato* (*q.v.*) The slur plays an important part in phrasing, and indicates that the first note under the slur is to be accented, and the last note unaccented and played *staccato* (*q.v.*), *e.g.*

DUSSEK.

As will be seen from the next example, the slur often removes the usual position of the accent:

DUSSEK.

An exception to this rule is when two notes in slow time or two long notes are slurred, also when groups of three, four, or more notes are slurred together, in which case the slur signifies simply *legato*; should the slur, however, extend to the accented notes, as in the following example, the above rule holds good:

WEBER.

In vocal music the slur indicates that those notes "slurred" are to be sung to one syllable. In stringed instrument music the slurred notes are played by one stroke of the bow. *See also* STACCATO *and* TIE.

—— (*Print.*) When from any cause during the actual process of printing the impression is smeared, it is said to slur.

Slype (*Architect.*) A mediæval name for a narrow passage between two buildings.

Sm (*Chem.*) The symbol for SAMARIUM (*q.v.*)

Small Capitals (*Typog.*) Of a smaller size than the regular capitals of a fount. They are used for running titles, chapter headings, side headings, and for emphasising certain phrases, proper names, etc.

Small Circle (*Geom.*) The circle formed by the intersection of the surface of a sphere with any plane cutting it, but not passing through the centre. *See* SPHERE.

Small Octave (*Music*). The octave between tenor C and middle C. *See* PITCH.

Small Pica (*Typog.*) Type between Pica and Long Primer in size. *See* TYPES.

Small Post (*Paper.*) A sheet of writing paper measuring 19 × 15½ in.

Smalt. *See* COBALT COMPOUNDS.

Smaltine (*Min.*) Cobalt diarsenide, $CoAs_2$; composition variable as a passage to Cloanthite (nickel diarsenide) is observed. Cubic, in brilliant tin white crystals; also massive. It is usually associated with other ores of cobalt and with ores of copper, silver, nickel, and arsenic. From Cornwall, Force Crag in Cumberland, Argyllshire, and Stirlingshire. More abundantly abroad at Freiberg, Schneeberg, and Annaberg in Saxony, in Bohemia, Tunaberg in Sweden, Chili, Missouri, etc.

Smalto (*Dec.*) Roman mosaic work, composed of very small squares of coloured glass.

Smelting (*Met.*) The separation of metals from their ores by the combined agency of heat and chemical action. The process usually requires the addition of FLUXES (*q.v.*), and oxidising or reducing agents which may consist entirely of gases formed in, or introduced into, the furnace. *Cf.* MELTING. *See also* METALLURGY.

Smith (*Eng.*) A general term for a mechanic who forges metals with a hammer, but often distinctively applied to a blacksmith, *i.e.* one who produces wrought-iron work, as distinguished from a coppersmith, tinsmith, and whitesmith.

Smith's Shop *or* **Smithy.** A forge; a workshop provided with hearths and anvils, etc., and in a large shop with power hammers, cranes, and other machinery.

Smithsonite (*Min.*) In Britain this term is sometimes used for HEMIMORPHITE (*q.v.*); but it has been used in America for the Carbonate of Zinc, CALAMINE.

Smoke. The gaseous products of combustion mixed with other gases given off by fuel, together with a great number of fine particles of unburnt carbon. Smoke thus consists largely of fuel which is being wasted.

Smoke Box (*Eng.*) A chamber in a locomotive or other fire-tube boiler at the end of the tubes or flues opposite to the fire-box. The products of combustion collect in the smoke-box in their passage to the smoke-stack. *See* BOILERS.

Smokeless Coal (*Eng.*) Anthracite and similar varieties of coal. *See* COAL.

Smooth Cut File (*Eng.*) One with a considerable number (*e.g.* 70) of teeth to the inch.

Smoother (*Foundry*). *See* SLEEKER.

Smoothing Plane (*Carp. and Join.*) This tool is used for smoothing the surface of wood after the jack and trying plane have been used. *See also* PLANES.

Smorzando, Smorzato (*Music*). Smothering the tone; equivalent to morendo.

Smudge (*Plumb.*) A mixture of lampblack, chalk, etc., used to prevent solder from adhering to lead where not required.

Sn (*Chem.*) The symbol for TIN (*q.v.*)

Snap (*Eng.*) The cup-shaped tool used for closing or forming the head of a rivet. The tool is held over the head of the redhot rivet and struck with a hammer.

Snap Head Rivet (*Eng.*) A rivet with a cup-shaped head, formed by a snap.

Snarls (*Cotton Spinning, etc.*) Twisted loops or kinks which appear at intervals on a thread; caused mainly by uneven tensioning or bad setting of the faller mechanism and carriage of a mule.

Sneck (*Build.*) A local term for a latch or door fastening.

Snecked Rubble (*Build.*) Masonry formed of rough irregular stones, but arranged in such a manner as to secure an effective bond.

Snell's Law (*Light*). When a ray undergoes refraction (*q.v.*) in passing from one medium to another, there is a ratio between the sine of the angle of incidence and the sine of the angle of refraction which is constant for any pair of media, or

$$\frac{Sin\ i}{Sin\ r} = \mu.$$

See also REFRACTION *and* INDEX OF REFRACTION.

Snifting Valve (*Eng.*) A valve used to allow the escape of gases, water, etc., from an enclosure when the pressure exceeds a certain amount; also called a BLOW VALVE or TAIL VALVE.

Snips. Shears for cutting zinc, tinplate, etc.

Snow (*Meteorol.*) Snow consists of the aqueous vapour of the atmosphere precipitated in the form of light, loosely packed masses of ice crystals. It may be said that one foot of snow represents roughly about one inch of rain.

Snow Guards (*Build.*) Iron rails, etc., fixed at the eaves of a roof to prevent the sudden fall of large masses of snow from the roof.

Snow Line (*Meteorol.*) A line that marks the height below which all the snow that falls annually melts during the summer. Above this line lies the region of perpetual snow.

Soakers (*Plumb.*) Pieces of lead or zinc fixed in the angle at the junction of a wall and the slates on a roof in order to prevent the rain running down the wall inside the roof.

Soaking (*Met.*) Allowing a freshly cast ingot of steel to remain in a SOAKING PIT (*q.v.*) in order that its temperature may become uniform throughout, prior to rolling. If allowed to cool in the air the outside cools much more rapidly than the interior, which may remain in a fluid condition for some time.

Soaking Pits (*Met.*) A bed of brickwork moulds in which the freshly cast *steel* ingots are placed as soon as stripped. When once heated, the pits are kept hot by the fresh ingots. They are usually built below the floor of the rolling mill, and kept covered to exclude air.

Soap. In popular language this is a substance soluble in water and possessed of lathering and detergent properties. These qualities are practically restricted to the soaps of alkali metals. A soap is a salt of which the basic radicle is a metallic oxide, while the acid radicle is derived from a fatty acid. Fats, such as tallow or linseed oil, are compounds in which the radicle of an acid replaces hydrogen in glycerine. The acids concerned are therefore called fatty acids, and in the making of a soap from a fat the glycerine is formed and set free. Many of the soaps are, however, far from conforming to the popular conception of a soap. The term "soap" is practically confined to the potash and soda salts of the highest members of the fatty acid series, especially palmitic acid and stearic acid. With potash we get soft soaps, with soda hard soaps, and intermediate varieties by the use of both alkalies. The soaps of the heavy metals are insoluble; and although they have their uses, they refuse to wash anything. The manufacture of soap is of considerable antiquity, but cannot be traced back much before the beginning of the Christian era. Pliny describes a product from goat tallow and wood ashes, and Pompeii possessed a soap factory. Of the chemistry of soap nothing was known before the time of Chevreul. The PROCESSES OF SOAP MAKING fall under two great heads. In one set the fat itself is treated with the alkali direct; in the other the fatty acid is first prepared from the fat and then treated with the alkali after the separation of the glycerine also formed. The former principle was the only one used until comparatively recently; but the latter is fast gaining ground, and seems likely to supplant its older rival altogether. One great reason of this is, that when the new methods are adopted it is far cheaper and easier to extract the glycerine (which has a higher price than most soaps) than is the case when the fat is saponified direct. The indirect saponification methods, if the term may be allowed, are again subdivisible into two. In one the fatty acid is produced by chemical means, and in the other the production of acid and glycerine is the result of the action of an enzyme from a seed, especially from the seeds of the castor oil plant and those of the wild liquorice (*Abrus precatorius*). Taking the older method of direct saponification first, we find that to make a hard soap the fat is boiled with a caustic soda lye until the whole of the fatty acid has been converted into the alkaline salt. The quantity required for a given weight of the fat (or, more usually, mixture of different fats) is roughly known, and gradient tests exist by which the progress of the saponification may be estimated. When saponification is complete the soap is in a state of solution in the water present, and must be precipitated. This process is called RELARGING, and is done by throwing in dry common salt. This dissolves in the water, and forms a solution in which the soap is insoluble. It therefore rises to the top in the solid form, and the sub-lye, containing the salt and glycerine, is run out from beneath it. Before relarging, the soap maker judges by the taste or "touch" whether the soap contains too large an excess of alkali or too large an excess of fat, adding more of one or the other as may be required. When the sub-lye has been drawn off, the soap is finished or clear boiled by boiling with lye too strong to dissolve it. This purifies it, and the sub-lye having been again run off, the soap is ladled into the frames, where it sets. In some cases in making high priced soaps, a "cleansing boil," or even two, is given after finishing. This is done with strong salt water, and its object is to free the soap from dirt and any excess of alkali. A soft soap is much simpler to make, as no relarging is required. The above description is an outline of a typical process, but the details vary almost indefinitely, according to the fat used and the purpose for which the soap is intended. Soaps are, of course, MEDICATED, SCENTED, and DYED in many ways. In the best soaps the drug or scent is added by milling, *i.e.* cutting the soap into thin shavings, which are then wetted with the liquid to be incorporated and again made into cakes or bars by being pressed through a moulder. A majority of the soaps upon the market are "filled." FILLINGS: Soap has the power of incorporating with and holding

large quantities of foreign matter. Rosin, common salt, potassium chloride, potassium and sodium sulphates, farina and water glass, are all common fillings. They are to be regarded as adulterants pure and simple, as they are cheaper than soap and do not possess its useful properties. It is true that rosin makes salts analogous to soaps with metallic oxides; but these soaps, like lime soap or iron soap, are soaps only from the point of view of chemical classification. Rosin is added during saponification, the other fillings at the final stage before framing or even while the soap is setting in the moulds. The glycerine is sometimes incorporated with a soap—especially in the toilet soaps made by the so-called "cold process," *i.e.* by extra strong lyes at temperatures well below boiling heat—but cannot be called a filling, as it is an essential part of the fat from which the soap is made. In former times, soap boilers made their own caustic alkali from quicklime and the carbonate of the alkali. This practice has been lessening ever since caustic soda could be cheaply bought ready made; but it still prevails to some extent on the Continent, particularly in Russia. When a soap is to be prepared by the INDIRECT CHEMICAL PROCESS, the fatty acid is simply neutralised with the alkali or its carbonate. There is no glycerine, and very little finishing is needed, as the fatty acid is always much freer from foreign matter than the original fat. The fermentation method for producing the fatty acids consists of making a pulp of the seeds of *Ricinus*, or of the plant chosen, and keeping it in the warm fat in the presence of mineral acid. It is claimed for this method that the glycerine obtained pays all the expenses, so that the whole of the money received by the sale of the soap is clear profit. ROSIN SOAP is used, as already stated, as an adulterant of ordinary soaps, but is also employed as a raw material for making other resinates, some of which, such as the resinates of lead and manganese, are used as dryers by varnish makers. If rosin is boiled in solution of carbonate of soda, carbonic acid gas is given off, and a solution of soda combined with resinic acid is left. If, say, nitrate of lead is added to the solution of resinate of soda, resinate of lead is obtained as a precipitate. Other resinates of heavy metals are obtained by similar methods. Rosin soap enters into the composition of some of the waterproofing mixtures. Several patents have been taken out for using the soaps of the heavy metals, such as the oleate, stearate, and palmitate of alumina, in waterproofing. Lead plaster, or oleate of lead, is a well known insoluble soap used in medicine. LIME SOAPS are used in making cheap lubricants, and on the Continent are precipitated from waste baths of ordinary soap for the preparation of illuminating gas. The soaps of alumina, zinc, and magnesium are used to increase the viscosity of heavy machine oils. In candle making, lime soap is largely used, and it is also employed in making fatty acids, the fat being saponified with milk of lime under a pressure of 160 to 180 lb. to the square inch, and the lime soap being afterwards decomposed with dilute sulphuric acid, which forms sulphate of lime and sets free the fatty acid. The acid rises to the surface of the water, and is skimmed off, while the insoluble sulphate of lime forms a sediment at the bottom. With the exception of lime soap and lead plaster, no heavy metal soap is made by direct saponification. LEAD PLASTER is prepared by heating olive oil with litharge and lime soap, as just described. The others are obtained as precipitates by adding a solution of a metallic salt to one of common soap. Many of these insoluble soaps have pronounced colours, and the mottling of soap is occasionally effected by stirring in a little solution of iron, which throws down its equivalent of dark iron soap. Nowadays, however, mottling is done chiefly by stirring ultramarine or black oxide of manganese into the soap in the frames, choosing the time for doing so as late as possible, that the mottling may not accumulate at the bottom. The heavy pigment would rapidly sink if the soap were fluid enough. POLISHING SOAPS are ordinary curd soaps into which some abrasive material, such as ground pumice stone, fuller's earth, prepared chalk, kieselguhr, etc., has been crutched before allowing the paste to cool in the frames. In the same way disinfecting products are also introduced. SOAP POWDER is chiefly ground washing soda (or sometimes ordinary soda ash), mixed with varying percentages of dried soap, as it comes from the frames. DYEING SOAPS are ordinary household soaps to which aniline dyes (with a mordant, if necessary) have been added prior to cooling. So-called superfatted toilet soaps have some emollient, such as lanoline, vasceline, spermaceti, incorporated by remelting or milling. The object is to correct any excess of free alkali, which tends to roughen the skin. The following are a few typical analyses of soaps:—

	Fatty Anhydrides.	Combined Alkali	Free Alkali.	Salt.	Sulphate of Soda.	Water, etc.
Tallow Curd . . .	66·60	7·51	0·50	1·35	0·2	23·84
Bleached Palm . . .	66·20	7·83	0·40	2·0	trace	28·52
Imitation Castile . .	61·45	8·46	1·16	1·17	1·23	26·53
Milled Toilet . . .	83·6	9·8	0·24	—	—	5·36
Primrose	*46·88	7·12	0·14	0·14	0·07	30·25
Olive Marseilles, No. 1	62·66	7·27	0·80	0·76	0·8	32·51
The Transparent Soaps						
Cold process . . .	38·0	5·57	2·22	—	—	55·53†
Spirit process filled with sugar . . .	65·6	7·73	—	—	—	26·67‡
Spirit process without sugar . . .	68·1	7·62	—	—	—	24·28

* Also 15 per cent. of resinous anhydrides.
† 28 per cent sugar. ‡ 14 per cent sugar.

Among soft soaps the following are typical:—

Soap.	Fatty Acids.	Alkali (K_2O).	Water, Salts, Glycerine, etc.
Rape Oil . . .	51·7	10·0	38·3
Olive	48·0	10·0	42·0
London make .	45·0	8·5	46·5

See also SOFT SOAPS, WHITE SOAP, YELLOW SOAP.

Soap Bark (*Botany*). The soap tree of South America (*Quillaia saponaria*; order, *Rosaceæ*) yields the soap or Panama bark used in medicine, and as a cleaning agent for silk and delicate fabrics.

Soap Bubbles (*Phys.*) The walls of a soap bubble are formed by a thin film of soap solution, which tends to contract owing to the surface tension of its two surfaces; this tendency to contract is counteracted by the pressure of the enclosed air or other gas, which is always greater than the pressure of the external air. If p be the difference between the internal and external pressures, T the surface tension of the bubble, and r its radius, then $p = \frac{4T}{r}$.

Soapstone (*Min.*) A massive variety of TALC (*q.v.*) It is used in the East for ornamental carving and turning. Commercially it is used in the manufacture of gas burners, as a dry lubricant, in the manufacture of porcelain, and on account of its absorptive property when in fine division for removing grease from cloth.

Soapsuds (*Eng.*) Used as a lubricant for the cutting tools in working wrought iron and steel.

Soave, Soavemente (*Music*). Sweetly, delicately.

Sock (*Archæol.*) The light low shoe worn by comic actors in Greek and Roman drama; the symbol of comedy. *Cf.* BUSKIN.

Socket (*Carp. and Join.*) The recess or opening into which the pin of a dovetail fits.

—— (*Eng., etc.*) A hollow or cavity into which some object fits, especially the enlarged end of a length of pipe. *See* FAUCET.

Socket Chisel (*Carp.*) A heavy mortising chisel with a tubular metal socket or handle, into which a wooden handle is fixed.

Socle (*Architect.*) A slab-like member, square in plan and less in height than in width, used under a pedestal or vase. A CONTINUED SOCLE is similar to the above, but is continued round a building, instead of being used only under certain members of it.

Soda (*Chem.*) A name loosely used to denote either sodium hydroxide or sodium carbonate. The context alone enables one to tell what is meant. In some analytical reports the word means sodium oxide, Na_2O. The term soda is not used, or only where no ambiguity can arise, by accurate writers on chemistry. *See also* ALKALI *and* SODIUM COMPOUNDS.

Soda Ash (*Chem.*) Dry commercial sodium carbonate. *See* ALKALI.

Soda Bleach. *See* SODIUM PEROXIDE, *under* SODIUM COMPOUNDS.

Soda Crystals (*Chem.*) Crystallised sodium carbonate, $Na_2CO_3 10H_2O$. *See* ALKALI.

Soda Nitre (*Min.*) Nitrate of sodium, $NaNO_3$. Soda = 36·5, nitric acid = 63·5 per cent. Rhombohedral; also in efflorescent forms. White, greyish, or brown. It is used in the manufacture of nitric acid and potassium nitrate. It occurs as a surface deposit on the Pampas of Chili. It is a common associate of Gypsum, Rock Salt, etc.

Soda Waste (*Chem.*) Same as alkali waste. *See* ALKALI; CHANCE'S PROCESS; *and* SODIUM THIOSULPHATE, *under* SODIUM COMPOUNDS.

Sodium (*Chem.*) Na. Atomic weight, 23. A silvery white metal which rapidly becomes coated with oxide on exposure to air. Hence it is kept under hydrocarbon oil in a well-stoppered bottle. On the large scale it is washed with oil and put up in hermetically sealed drums. At ordinary temperatures it is very soft, and can be moulded in a sodium press, but at −20° C. it possesses ordinary metallic hardness, and is malleable and ductile in an atmosphere that cannot oxidise it. It is one of the lightest of metals (sp. gr. = 0·973), and is fusible and volatile (m.p. = 95·6° C., b.p. = 742° C.); specific heat = 0·29 (solid) and 0·24 (liquid). Although generally seen in sticks, sodium can be crystallised in a similar manner to Prismatic Sulphur. Recent investigations show that the molecule of sodium is monatomic. When sodium or any compound containing it is introduced into a colourless Bunsen burner flame a vivid yellow flame is produced, even by extremely small quantities. Sodium is stable in perfectly dry air or oxygen, but it oxidises readily in moist air; reacts very energetically with water, replacing half the hydrogen at the ordinary temperature, and forming sodium hydroxide, $2H_2O + 2Na = 2NaOH + H_2$. It combines directly with sulphur and with the halogens; dissolves in liquefied ammonia, and reacts with gaseous ammonia to make sodamide (*q.v.*) It combines with hydrogen to make the hydride (NaH). Dilute acids have an energetic action on sodium, which is very high on the electro-positive scale; hence if it were practicable to employ it instead of zinc in a voltaic cell, a very high E.M.F. would be obtained. It forms only one important alloy, *viz.* with potassium. The alloy is fluid at ordinary temperature, and has the appearance of mercury; sometimes used in thermometers, as it is fluid up to 440° C. SODIUM AMALGAM is formed by putting clean pieces of metallic sodium very carefully into mercury in a porcelain mortar; much heat is evolved. The amalgam will slowly decompose water, and can be employed to amalgamate iron and platinum. It is also used as a reducing agent in organic chemistry and as a solvent in extracting gold and silver. Sodium occurs native, principally as common salt (sodium chloride), NaCl; also as borax (sodium pyroborate), $Na_4B_2O_7$, and as Chili saltpetre (sodium nitrate), $NaNO_3$. These salts, being soluble, could only be deposited in an almost rainless climate. Other sources of sodium are insoluble, *e.g.* the mineral cryolite, Na_3AlF_6, also the mineral Albite and the sodalite group of silicates. PREPARATION: in Castner's process fused sodium hydroxide is put in a large tank heated to about 330° C. The negative electrode or cathode at which the sodium comes off passes up into the liquid from below, and is surrounded at the top by wire gauze. The metal floats in the molten liquid, and is ladled out at intervals.—H. W. H.

Sodium Compounds. SODIUM MONOXIDE, Na_2O, although theoretically the normal oxide, is not the most important; obtained by heating sodium with the theoretical quantity of sodium nitrate,

$$10Na + 2NaNO_3 = 6Na_2O + N_2.$$

It is a grey, fusible powder, and is soluble in water without evolution of oxygen, $Na_2O + H_2O = 2NaOH$. SODIUM PEROXIDE, Na_2O_2. Sodium in thin pieces is placed on aluminium trays and allowed to travel slowly down iron tubes kept at 300—400° C. Air free from water and carbon dioxide is passed over and oxidises it. Sodium peroxide is a white, friable mass with a faint yellow tinge; not deliquescent when pure. Dropped into cold water it dissolves with scarcely any chemical action; but if cold water be dropped upon it, torrents of oxygen are evolved. This makes a convenient laboratory method for preparing oxygen. Sodium peroxide is decomposed by hot water, $2Na_2O_2 + 2H_2O = 4NaOH + O_2$. On moderate heating it simply darkens in colour. It acts violently on any oxidisable organic substance (*e.g.* it sets paper on fire). It is dangerous to heat it on charcoal or to add concentrated sulphuric acid to it. It sets fire to glacial acetic acid, absorbs carbon dioxide, and evolves oxygen; but the volume of the oxygen is only one-half that of the carbon dioxide, $2Na_2O_2 + 2CO_2 = 2Na_2CO_3 + O_2$. This may be used to prove the formula. Soda-bleach is a solution of this substance in dilute hydrochloric acid, and acts like hydrogen peroxide. SODIUM HYDROXIDE, NaOH (caustic soda): Obtained (1) as described under ALKALI (*q.v.*), (2) by precisely similar methods to

those described for potassium hydroxide. *See* POTASSIUM COMPOUNDS. Sodium hydroxide may be purified for use as a reagent by dissolving in alcohol and filtering, afterwards evaporating to dryness in a silver dish. Solid sodium hydroxide, on exposure to air, forms a viscous liquid by absorbing water, and afterwards becomes coated with carbonate by absorption of carbon dioxide. Soluble in water. with considerable rise of temperature; fuses at 310° C., and in the fused state attacks glass. For uses *see* ALKALI. SODIUM HYDRIDE, NaH (Moissan): Obtained by heating sodium in dry hydrogen to about 370°C.; forms white crystals (sp. gr. ·92), spontaneously inflammable in moist air. It liberates carbon from carbon dioxide; with water it gives caustic soda and hydrogen, $NaH + H_2O = NaHO + H_2$. SODIUM CHLORIDE, NaCl: Found native (impure) as rock salt; also obtainable by evaporating brine. Pure sodium chloride can be obtained from strong brine by leading a current of hydrochloric acid gas through it, thus increasing the concentration of chlorine ions and precipitating small crystals which are washed in strong hydrochloric acid. Pure salt is of a clean white colour, and is slightly deliquescent. It is about equally soluble in cold and hot water. Strong brine boils at 107·5° C. Besides its uses in the preparation of food it is employed in salt-glazing earthenware and in the manufacture of sodium carbonate and sodium hydroxide. SODIUM HYPOCHLORITE, NaClO. *See* HYPOCHLOROUS ACID. SODIUM CHLORATE, $NaClO_3$: Pass chlorine into hot milk of lime, and so form chloride and chlorate of calcium. To the mixture add salt cake (Na_2SO_4) and crystallise out. It is white and deliquescent. Unless mixed with potassium chlorate it is of no use for the preparation of oxygen. Its principal use is as an oxidising agent in organic chemistry. SODIUM FLUORIDE (NaF): Fuse dry sodium carbonate with fluorspar—

$$Na_2CO_3 + CaF_2 = 2NaF + CaO + CO_2.$$

The product is white and soluble. A solution of it is used in softening water for boilers. SODIUM SULPHITE (Na_2SO_3) *and* BISULPHITE ($NaHSO_3$) can be obtained as follows: (1) Saturate a known quantity of sodium hydroxide or carbonate with sulphur dioxide gas (this gives the bisulphite),

$$NaOH + SO_2 = NaHSO_3.$$

(2) Add the same quantity of alkali to the saturated solution (this gives the normal sulphite),

$$NaHSO_3 + NaOH = Na_2SO_3 + H_2O.$$

The bisulphite is the more useful as it contains a higher percentage of the valuable ingredient (SO_2). It is used as a reducing agent, and is employed in photography, bleaching, and as a disinfectant. It forms crystalline derivatives of fixed melting point, with aldehydes and many ketones. SODIUM METABISULPHITE, $Na_2S_2O_5$: Made by passing SO_2 over powdered washing soda, $Na_2CO_3 10H_2O$. It is white, crystalline, and soluble, and smells of sulphur dioxide. Used for the same purposes as the acid sulphite. SODIUM SULPHATE, Na_2SO_4: This substance is obtained most cheaply from the Stassfurt deposits. It can also be obtained by crystallising salt cake from the Leblanc process (alkali manufacture). It is used in glassmaking and in preparing other sodium salts. Its solution in water is a mild aperient (Glauber's Salts). SODIUM THIOSULPHATE (hyposulphite), $Na_2S_2O_3$: Prepare by adding sodium sulphate to calcium thiosulphate (obtained from alkali waste, calcium sulphide, by atmospheric oxidation),

$$Na_2SO_4 + CaS_2O_3 = Na_2S_2O_3 + CaSO_4.$$

Filter from the calcium sulphate and crystallise. The crystals are large and clear. They dissolve in water with fall of temperature; but the solution is not very stable. It is used in photography as "Hypo" to dissolve unaltered silver salts, and in chlorine bleaching as an Antichlor. In analytical chemistry it is employed in conjunction with standard iodine for estimating oxidising or reducing agents, $2Na_2S_2O_3 + I_2 = Na_2S_4O_6 + 2NaI$. SODIUM AMIDE *or* SODAMIDE ($NaNH_2$): Pass dry ammonia gas over heated sodium, $2Na + 2NH_3 = 2NaNH_2 + H_2$. It is a waxy mass of crystalline structure, and is chiefly interesting on account of two reactions: (1) With nitrous oxide (N_2O), on heating, it yields sodium azoimide, NaN_3 (*see* AZOIMIDE).

$$2NaNH_2 + N_2O = NaN_3 + NaOH + NH_3.$$

(2) On heating with carbon it yields sodium cyanide (used in extracting gold), $NaNH_2 + C = NaCN + H_2$. SODIUM NITRITE, $NaNO_2$: Take one part of Chili saltpetre to three of granulated lead. Fuse the saltpetre and add the lead in small quantities. The final product is extracted with pure water—

$$NaNO_3 + Pb = NaNO_2 + PbO.$$

A little caustic soda is also formed, and this tends to dissolve PbO; if this be exactly neutralised with nitric acid, the PbO will be precipitated. A new process consists in reducing sodium nitrate by carbon monoxide in the presence of quicklime—

$$NaNO_3 + CaO + CO = NaNO_2 + CaCO_3.$$

It forms colourless deliquescent prisms, stable on heating. It is used in the preparation of dye stuffs for the diazotisation of amines. If R be an organic radicle,

$$RNH_2 + NaNO_2 + 2HCl = R - N = N - Cl + NaCl + 2H_2O$$

SODIUM NITRATE, $NaNO_3$ (also called Chili saltpetre and cubic nitre): Obtained from beds just below the surface soil in Peru and Chili. Can be recrystallised if required pure. It is slightly deliquescent, which unfits it for many purposes (such as gunpowder making) to which potassium nitrate is applied. It is principally employed for manure and for preparing potassium nitrate and nitric acid, and on strongly heating it yields the nitrite with oxygen. SODIUM ORTHOPHOSPHATES (*see* PHOSPHORIC ACID): (1) *Tri* sodium phosphate, Na_3PO_4. Obtain by adding caustic soda in suitable quantity to a solution of common sodium phosphate and evaporating for crystals, $Na_2HPO_4 + NaOH = Na_3PO_4 + H_2O$. It is strongly alkaline to litmus, and absorbs carbon dioxide, which decomposes it. It is quite stable on heating, either alone or with carbon. It gives quantitatively a yellow precipitate with Silver Nitrate. (2) *Di* sodium phosphate (commonest form), $Na_2HPO_4 12H_2O$. Add sodium carbonate to phosphoric acid till no further effervescence. Filter and crystallise; large crystals, the solution of which gives a slightly alkaline reaction to litmus. On heating alone it yields the pyrophosphate (*q.v.*) When added to silver nitrate the silver is all precipitated, but the phosphate is not, and the liquid becomes acid to litmus.

$$3AgNO_3 + 2Na_2HPO_4 = Ag_3PO_4 + 3NaNO_3 + NaH_2PO_4.$$

(3) *Mono* sodium phosphate (NaH_2PO_4). Formed by passing a rapid current of carbon dioxide into a solution of common sodium phosphate. Large clear crystals with acid reaction. The solution does not completely precipitate silver nitrate. SODIUM AMMONIUM HYDROGEN PHOSPHATE, $NaNH_4HPO_4$ (Microcosmic salt), is a white solid crystallising in monoclinic prisms, which contain 4 molecules of

water; very soluble in water; decomposes on standing in air, forming sodium dihydrogen phosphate; when strongly heated it gives sodium metaphosphate—

$$NaNH_4HPO_4 = NaPO_3 + H_2O + NH_3.$$

On this account it is largely used in blowpipe analysis, as the sodium metaphosphate so produced has the property of dissolving many metallic oxides when melted, and on cooling characteristically coloured beads are obtained. Microcosmic salt occurs in guano: it can be made by mixing solutions of the common sodium and ammonium phosphates and allowing to crystallise, or by adding the requisite amount of ammonium chloride to a hot strong solution of common sodium phosphate, when common salt crystallises out and is removed, and the microcosmic salt crystallises out on cooling—

$$Na_2HPO_4 + NH_4Cl = Na.NH_4.HPO_4 + NaCl.$$

SODIUM PYROPHOSPHATE, $Na_4P_2O_7$: Obtained by heating common sodium phosphate, dissolving in water and crystallising—

$$2Na_2HPO_4 = Na_4P_2O_7 + H_2O.$$

Colourless crystals, alkaline reaction. Yields orthophosphate by boiling with dilute acids. SODIUM METAPHOSPHATE, $NaPO_3$: Easily obtained by fusing microcosmic salt and quickly cooling the clear bead, $NaNH_4HPO_4 = NaPO_3 + NH_3 + H_2O$. A deliquescent solid whose molecular formula is said to be $(NaPO_3)_6$. Coagulates albumen and gives a white precipitate with silver nitrate. SODIUM ORTHOBORATE, Na_3BO_3: Fuse B_2O_3 with caustic soda. Unstable product, $B_2O_3 + 6NaOH = 2Na_3BO_3 + 3H_2O$. SODIUM BIBORATE or Pyroborate, $Na_2B_4O_7$: This is common borax, and can be recrystallised from the native mineral. When heated it intumesces, and afterwards melts down into a clear glassy bead. Two different crystalline forms are known: (1) Octahedral, containing $5H_2O$, crystallising above 56°C. (2) Prismatic, containing $10H_2O$, formed below 56°C. Borax is used in cleaning because, (*a*) with water it yields by hydrolysis a certain number of hydroxyl ions, the detergent properties of which are well known. (*b*) On fusing it dissolves many metallic oxides, which act as films upon metallic surfaces. *See also* BORON COMPOUNDS. SODIUM SILICATES (*see* SILICON COMPOUNDS): An indefinite mixture called WATER GLASS is prepared by fusing finely divided flints with caustic soda under pressure to 200°C., and extracting with boiling water; also by fusing sodium carbonate and sand with a little charcoal till all carbon dioxide is expelled, and extracting with hot water. Colourless or yellow mass, semi-transparent. Decomposed when in solution by any acid, even carbonic. Used in fresco painting, for hardening the surface of stone, and for fireproofing wood. It is frequently added to the cheaper kinds of soap. SODIUM TUNGSTATE, $Na_2WO_4 2H_2O$: Fuse the mineral wolfram with sodium carbonate; extract with water and crystallise. It is used as a mordant in calico printing. SODIUM STANNATE, Na_2SnO_3: Fuse powdered tinstone with caustic soda, dissolve the resulting mass in water, and crystallise—

$$2NaOH + SnO_2 = Na_2SnO_3 + H_2O.$$

It is chiefly used as a mordant for Eosine and other dyes. It undergoes change on exposure to air, being decomposed by carbon dioxide. SODIUM CARBONATE (washing soda), $Na_2CO_3 10H_2O$: Prepared by the Leblanc method or Solvay method. *See* ALKALI. It is white and crystalline, very soluble in water, making an alkaline solution. The crystals undergo aqueous fusion at 50° C., then dry up and fuse at 850° C. (igneous fusion). SODIUM BICARBONATE, $NaHCO_3$: Prepared by the Solvay process. *See* ALKALI. It forms small prismatic crystals, and is less soluble than the normal carbonate. The crystals are decomposed by heat—

$$2NaHCO_3 = Na_2CO_3 + CO_2 + H_2O.$$

The solution is faintly alkaline, and on heating gives off CO_2. When a little of this substance is mixed with flour and water and heated, the weak vegetable acids in the flour cause a gentle evolution of CO_2; thus the substance acts as baking powder. SODIUM SESQUICARBONATE, $Na_3H(CO_3)_2 + 2H_2O$, is found native as Trona, and has been known from early times. SODIUM FORMATE, $NaHCO_2$, or $HCOONa$: Neutralise some caustic soda with formic acid solution. Forms a white deliquescent substance, giving sodium oxalate on heating—

$$2HCOONa = Na_2C_2O_4 + H_2.$$

It is a reducing agent, *e.g.* reduces silver nitrate. SODIUM ACETATE, $NaC_2H_3O_2$, or CH_3COONa: Treat pyroligneous acid, obtained from the distillation of wood, with caustic soda till neutral; evaporate, and heat the residual sodium acetate till it fuses; then recrystallise. It forms transparent and easily soluble prisms. Its principal use is, in analysis, to remove strong acidity from a solution. Suppose a solution contains free HCl (ionised), the addition of sodium acetate replaces this by free acetic acid (almost non-ionised),

$$\overset{+}{H}\,|\,\overset{-}{Cl} + \overset{+}{Na}\,|\,CH_3COO = \overset{+}{Na}\,|\,\overset{-}{Cl} + HCH_3COO.$$

SODIUM PHENATE, NaC_6H_5O, or $NaOC_6H_5$: Formed by dissolving phenol (carbolic acid) in sodium hydrate. It is white, becoming brown on exposure, and is one constituent of "carbolic soaps," being antiseptic and detergent. (For other sodium salts *see under* the particular acid.) H. W. H.

Sod Oils. The oils expressed from skins which in the process of currying have been treated with cod, whale, or olive oils. The French product (Möellon) is obtained from skins used solely for this purpose. When refined, genuine sod oils are valuable for lubricating watches and similar delicate mechanism. There are many artificial or substitution mixtures that pass under the name. *See also* DEGRAS *and* RAISING.

Soffit (*Build.*) (1) The under surface of an arch. (2) The underside of a flight of stone steps. (3) The head lining of an opening. (4) The under horizontal face of an architrave between columns.

Soft (*Silk Manufac.*) Silk from which the natural gum has been removed by a process called "boiling off," in which it loses about 25 per cent. of its weight, and becomes bright and lustrous. *Cf.* SOUPLE.

Soft Brass (*Eng., etc.*) Brass which has been annealed. *See* ANNEALING.

Softener. A large brush used in shading mechanical drawings.

—— (*Paint.*) A large soft brush used for disposing colour evenly, or for blending colours freshly laid on the canvas.

Soft Ground Etching. *See* ENGRAVING AND ETCHING.

Soft Iron (*Eng.*) The term applied in a general sense not only to wrought iron, but also to cast iron, which can be dealt with fairly easily in the lathe or by other machine tools.

Soft Paste (*Pot.*) A term applied to porcelain, the body of which is of a composite character. In its manufacture the greatest heat is given in the

"bisque" (*q.v.*), which is thereby rendered translucent and non-porous. The glaze is fired at a lower temperature, and is therefore a "soft" glaze, lying upon the surface of the body. *See* HARD PASTE, GLOST OVEN, *and* POTTERY AND PORCELAIN.

Soft Soap. A transparent, jelly-like substance made from oil and potash. The oils vary considerably, whale and seal oils, linseed oil, and tallow being sometimes employed, while fish oil is not infrequently used; hence the disagreeable smell which characterises some makes of soft soap. Soft soap is used largely in linen bleaching works, as a basis for insecticides, for greasing the ways of docks, and for domestic purposes. *See* SOAP.

Soft Solder. Solder composed of lead and tin, which has a low melting point and is easily worked with a soldering iron.

Soft Water. Water free from the salts of calcium, etc. *See* CALCIUM COMPOUNDS, CLARK'S PROCESS, *and* WATER.

Soft Woods (*Carp.*) This term, as applied by carpenters and joiners, usually includes the coniferous woods—firs, pines, etc.; but the term is not used in an exact sense.

Soh (*Music*). The fifth degree of the scale in "movable doh" system.

Soil, Formation of (*Geol.*) Soil is usually a mixture, in variable proportions, of clay and sand, often with rock fragments, and with more or less organic matter, chiefly of vegetable origin. Soils are primarily due to the decomposition of rocks in general, and have been brought into their present position by the separate or combined action of a large number of natural causes. Amongst these causes the influence of gravitation plays the most important part. The transporting agents include: (*a*) Water in motion, which gives rise (1) to "rain wash" on a hill slope, (2) to lacustrine deposits, (3) to flood loam on the plains, and to other initial forms of soils. (*b*) The action of the wind in transporting dust from one locality to another, where it may be arrested by encountering a damp surface, as may be seen on a small scale in the patches of moss on a wall, or of house-leek on a cottage roof, or it may be temporarily fixed by filtration through vegetation, which checks the velocity of the air current, and thus lessens its transporting power. (*c*) The continual action of worms in bringing up the finer materials from the lower layer of the subsoil and leaving them at the surface. (*d*) Rain, which intercepts large quantities of dust from the lower part of the atmosphere, and deposits these on the surface. In the neighbourhood of large towns great quantities of soot are washed out of the air by the agency of rain, and thence into the soil. Dead vegetable matter forms no inconsiderable portion of many soils. On upland hill slopes facing northward, or otherwise long out of the sunshine, this vegetable matter tends to change into peat, which is an important constituent of many soils in mountain districts.

Soil Pipe (*Plumb.*) The pipe connecting a closet trap with the sewer.

Soils (*Hygiene*). In cold and temperate climates, sands and gravels, if fairly deep and without a substratum of clay, are the warmest and the driest. The next best soils are rocks, such as granites, limestones, and sandstones. Clay soils are cold, and, owing to their impermeability, damp. Pure chalk is permeable; but if mixed with or underlaid by clay, it becomes impermeable and damp. Shallow beds of gravel or sand lying on clay are bad, as they are liable to become waterlogged. *See* SANITATION.

Sol (*Music*). The sol-fa name for G.

Solano (*Meteorol.*) A south-east wind, extremely hot and loaded with fine dust. Peculiar to Spain. The Spanish proverb "Ask no favour during the Solano" expresses its effect on man.

Solar Attachment (*Surveying*). An addition to the theodolite which enables the true meridian to be determined.

Solar Constant (*Astron.*) The number of heat units which a square unit of the earth's surface, unprotected by any atmosphere, and exposed perpendicularly to the sun's rays, would receive in unit time. *See* RADIATION.

Solar Heat (*Astron.*) *See* SOLAR CONSTANT.

Solar Radiation (*Phys.*, *Meteorol.*, *etc.*) The transmission of radiant energy from the sun to the surrounding space, and in particular to the surface of the earth.

Solar Spectrum (*Phys.*) *See* SPECTRUM.

Solar System (*Astron.*) The system in which are included the sun, all the planets with their satellites, and minor planets.

Solar Time, Apparent (*Astron.*) *See* MEAN SOLAR DAY.

Solder. A fusible alloy used to form a joint in certain metals. *See* SOFT SOLDER, HARD SOLDER, *and* SOLDERING.

Solder Dot (*Plumb.*) A small drop of soft solder used to cover the heads of screws employed in fixing sheet lead.

Soldering. Uniting metallic surfaces or forming joints by means of a fusible alloy (*see* SOLDER). The efficiency of soldering depends on the intimate union of the surface of the metal operated upon with the alloy used as a solder. To effect this the surfaces are carefully cleaned, and in most cases a flux is used during the operation, *e.g.* resin or a solution of zinc chloride in soft soldering, or borax in hard soldering. The flux assists in removing oxide, etc from the metal while in the heated state. A suitable quantity of solder is applied to the joint, and fused by the application of a heated soldering iron or the blowpipe flame. As the joint becomes hot, the solder melts, and runs, under the action of surface tension, along the portions which have been prepared and heated to the proper temperature. Soft solder is easily caused to follow the track of the soldering iron as it is drawn along the joint; but hard solder, which always requires the heat of a blowpipe, is more difficult to manipulate, and the surfaces to be soldered require very careful preparation. Solder must of course have a melting point which is lower than that of the metals to be united. *See also* SOLDERING IRON, HARD SOLDER, *and* SOFT SOLDER.

Soldering Iron *or* **Bit.** A tool consisting of a short thick rod of copper, mounted on an iron stem, with a wooden handle. The end of the copper portion, or BIT, is either pointed or chisel shaped. In use the bit is heated, rapidly cleaned, and TINNED or coated at the end with solder, when it is ready to be applied to the joint. *See* SOLDERING.

Soldering Tongs. Tongs with a flat nose, used for brazing the joints of band saws.

Sole. A highly esteemed food fish, *Solea vulgaris*, common to Europe.

Sole *or* **Sole Plate** (*Eng.*) A base or bed plate.

Soleil (*Textile Manufac.*) *See* OTTOMAN RIB.

Solennemente (*Music*). Solemnly.

Solenoid (*Elect.*) A coil of wire wound into the form of a helix; a tubular coil.

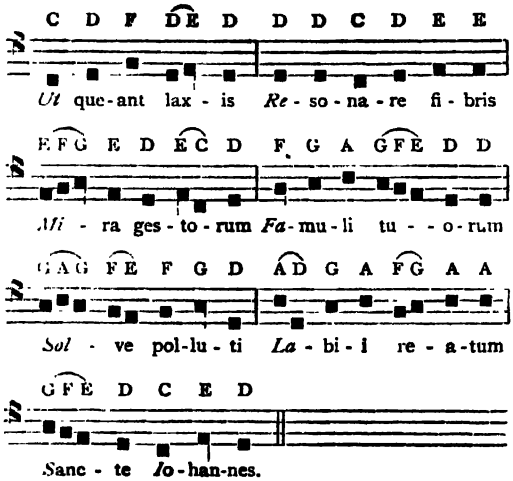
Solenoidal Filament (*Magnetism*). A linear magnet, *i.e.* one whose breadth and thickness are negligible. It may be either straight or curved.

Sole Piece (*Carp. and Join.*) *See* FOOT BLOCK.

Sol-fa (*Music*). Sol-fa-ing is singing notes to syllables instead of words. The syllables are:

(Do) Ut, Re, Mi, Fa, Sol, La, Si.
C, D, E, F, G, A, B.

The first six syllables are supposed to have been invented by Guido d'Arezzo at the beginning of the eleventh century, "as an aid to pupils in learning to read music," and were taken from the first syllable in each division of a festival hymn to St. John the Baptist, the music to which (composed about 770), it will be observed, begins on the six ascending notes of the scale, C to A:



The seventh syllable Si appears to have been added at the beginning of the seventeenth century, and to have been suggested from the initial letter of the two words in the last line, S, I. About the same time Do was substituted for Ut in Italy and England, as being more euphonious, and has been almost universally accepted. The oldest form of Solmisation, *i.e.* the art of using syllables to illustrate the scales, was employing Ut or Do for the Tonic, and we now speak of this as the Movable Do. This mode of using the syllables has the advantage of fixing in the student's mind the relationship of the several notes of the scale, as Tonic, Dominant, Leading note, etc., irrespective of absolute pitch, and of compelling him to determine the different modulations of key in a piece; whereas the Fixed Do depends on absolute pitch, or rather on the study of intervals. *See also* TONIC SOL-FA.

Solfatara (*Geol.*) A volcanic vent amongst the recently extinct volcanoes west of Naples, whence sulphurous and other fumes come forth into the air, and where the products arising from the condensation of these fumes collect in the solid form on the cooler rocks around the vent. These sublimed products include a large number of substances of use in the arts, of which, as the name Solfatara suggests, sulphur is one. Similar vents from which arise emissions of various substances, volatile at a low temperature, are of common occurrence elsewhere in the neighbourhood of dormant and recently extinct volcanoes, to most of which the name solfatara is now usually applied. Hence volcanoes which have quieted down to the condition in which gaseous emissions have taken the place of the normal eruptions are said to have passed to the solfataric stage. The acid fumes give rise to some important modifications of the volcanic materials around the vent.

Solfeggio (*Music*). An exercise for the singing of music to the sol-fa syllables. Amongst the best known of the more easy "solfeggi" may be mentioned Concone's exercises. Solfeggi must not be confused with exercises in vocalisation; the latter consist of singing to one vowel, and not to different syllables. *See* SOL-FA.

Soli (*Music*). One to each part.

Solid. That form of matter in which the molecules lie close together with little freedom of movement, and in which they cannot be separated except by the application of a definite amount of force. Maxwell defines a solid as a body which can sustain a longitudinal pressure without being supported by a lateral pressure.

Solid Angle. Three or more surfaces which intersect at a point are said to form, or to include, a Solid Angle, *e.g.* there is such an angle at the top of a pyramid or at each corner of a cube. The solid angle subtended at a point by any given area is that formed by drawing lines from the given point to every point in the boundary of the area. The magnitude of the solid angle so formed is the area cut off on a sphere of unit radius by the irregular cone formed by the lines.

Solid Drawn Tube (*Eng.*) Metal tubing which has been formed by forcing or drawing the metal in a fluid or plastic condition over a mandrel or series of mandrels; a tube is thus formed which has no joint or seam. Lead, copper, brass, iron, etc., can be thus treated.

Solid Frame (*Carp. and Join.*) A thick frame, with the rabbet and moulding worked on the solid stuff.

Solidification. The process of becoming solid; freezing, crystallisation, etc.

Solid Matter (*Typog.*) Type set without space or leads between the lines.

Solid Rolled Girder (*Eng.*) A girder rolled in one piece instead of being built up. *See* GIRDER.

Solleret (*Arm.*) *See* ARMOUR.

Solmisation (*Music*). *See* SOL-FA.

Solo (*Music*). Alone; a composition for one voice or instrument.

Soloist (*Music*). One who performs alone, either with or without musical accompaniment.

Solo Organ (*Music*). The manual of an organ having stops of a solo character, and imitating as nearly as possible the different orchestral tones, such as flutes, clarionet, orchestral oboe, trumpet, tuba, etc.

Solstices (*Astron.*) The times when the sun is at its greatest distances from the equator. The dates are June 21 and December 22; the day is longest at the first or summer solstice, shortest at the second or winter solstice, in the northern hemisphere.

Soluble Blue. *See* DYES AND DYEING.

Soluble Castor Oil. Generally applied to castor oil that has been hydrolysed with sulphuric acid to make Turkey red oil. It is also applied to castor oil which has been "blown" in its preparation as a lubricant, after which it becomes miscible with petroleum hydrocarbons.

Soluble Glass. A silicate of sodium prepared by fusing sodium carbonate and silica. It has a glassy appearance; hence the name SOLUBLE GLASS, or WATER GLASS. It is used as a preservative for certain limestones, as it combines with the calcium to form an insoluble silicate. It is also used as a mordant in calico printing, for preserving eggs, filling soap, and other purposes.

Solute. A dissolved substance.

Solutions (*Chem.*) "Homogeneous mixtures which cannot be separated into their constituent parts by mechanical means, the proportion between the parts being continuously variable between certain limits, with a corresponding continuous variation in properties" (*Whetham*). The components of any given solution may be elements or compounds, or both, and there is no restriction as to physical state. For example, sea water is a solution of many solids and several gases in the liquid water; many alloys are examples of solid solutions, so also are mixed crystals. A few cases of solution are briefly considered in what follows. GASES IN WATER: All gases dissolve in water, but in very unequal amounts. Thus one volume of water at 0° dissolves 1,270 volumes of ammonia, but only ·0226 volume of hydrogen. When a gas is very soluble in water, chemical change occurs on solution; ammonia, for example, forms the ions $\overset{+}{HN_4}$ and $\overset{-}{OH}$. Again, hydrogen chloride forms the ions $\overset{+}{H}$ and $\overset{-}{Cl}$. Where no action occurs between the gas and water, Henry's Law (*q.v.*) holds; in the case of a mixture of gases, a simple extension of this law holds—every constituent of the mixture behaves as if the others were absent; this is sometimes called the Law of Partial Pressures. The solubility of gases in water diminishes with increase of temperature; by solubility of a gas is meant the volume of the gas divided by the volume of the water in which it is dissolved at any given temperature and pressure. The halogen acids are exceptions to this statement, for starting with a saturated solution of hydrogen chloride, for instance, at 0° and 760 mm., and keeping the pressure constant, the solution changes in strength from about 45 per cent. by weight of hydrochloric acid to 20·24 per cent., as the temperature rises to 110°. LIQUIDS IN LIQUIDS: Some liquids are miscible in all proportions, as alcohol and water; others are partially miscible, as ether and water. When these two are shaken together, enough of each being taken, two layers separate on standing, the upper one being a solution of about 3 per cent. of water in ether, and the lower one a solution of about 10 per cent. of ether in water; others are practically non-miscible, as water and oil, or water and carbon disulphide. In the first case the mixture may boil below the lower boiling constituent, above the higher boiling constituent, or between these two. When the vapour pressure of the mixture attains a maximum value, then, on boiling, a mixture first approximating to and finally attaining the composition corresponding to this maximum vapour pressure will distil over, and that constituent which was in excess will remain behind. An example of this kind is a mixture of propyl alcohol and water. When the vapour pressure of the mixture attains a minimum, then, on boiling, that constituent which is present in excess will distil over, and a mixture will remain behind corresponding in composition to the mixture of minimum vapour pressure. An example of this kind is a mixture of water and formic acid. When the mixture has no maximum or minimum vapour pressure, then, on boiling, the lower boiling mixture will come over first; thus a mixture of water and methyl alcohol can be completely separated by distillation. In the second case (partially miscible liquids) it is clear that if the solubility of one liquid A in another B increases with temperature, while the solubility of B in A diminishes with rise of temperature, then there will be a temperature at which the liquids are miscible in all proportions; this is the case, for example, with aniline and water, which are miscible at 114°, phenol (melts at 42°), and water at 80°. Again, the vapour pressure of a solution of A in B must be equal to the vapour pressure of a solution of B in A, when both solutions are saturated at the same temperature; hence on distilling together the two layers formed by shaking two partially miscible liquids, distillation will proceed at a constant temperature so long as the two layers remain, and the distillate will have a constant composition. The boiling point may be above the boiling point of the higher boiling constituent, below that of the lower boiling constituent, or between the two, according to the degree of miscibility, the difference between the boiling points, and the effect of the vapours on each other. The third case need not be considered. An interesting special case illustrating these cases is the following, due to Professor Young. Alcohol forms mixtures of minimum boiling point (*i.e.* maximum vapour pressure) with water at 78·15° and with benzene at 68·25°, and is miscible with these liquids in all proportions. Benzene is not miscible with water, so that when the two are heated together they boil below the boiling point of benzene, *viz.* at 69·25°. When a mixture in suitable proportions of all three is distilled, a constant boiling fraction of all three might be expected to come over at a temperature below any of the above; then should one constituent be removed in this way the ternary fraction would be followed by a binary fraction boiling below either of its constituents. Lastly, the binary fraction should be followed by that single constituent which was initially in excess. Now, in fact, if a mixture of equal weights of benzene and strong alcohol (93 per cent. by weight alcohol) be distilled in an efficient fractional distillation apparatus, these results are very nearly obtained; the ternary mixture, alcohol, water, benzene, comes over at 64·84°, it is followed by a mixture of benzene and alcohol; and finally alcohol containing only 1·4 per cent. of water and a trace of benzene comes over. On redistilling this last fraction with benzene, absolute alcohol can be obtained. SOLIDS IN WATER: The solubility of a solid in water is expressed in three different ways: (*a*) in ordinary solubility determinations, as grams in 100 grams of water; (*b*) in volumetric analysis, and sometimes in the theory of solutions, as grams in 100 cc. or 1000 cc.; (*c*) commonly in the theory of solutions, as gram molecules per litre; in all cases the temperature is stated or understood to be the ordinary temperature, 15°; the pressure need not usually be stated, as its effect on solubility is very small. Solids differ enormously in solubility in water; *e.g.* barium sulphate, which is for practical purposes insoluble, is only soluble to the

extent of ·00025 grs. in 100 cc. of water at 18°, while at the same temperature 100 grams of water dissolve 203 grams of cane sugar. Ordinarily increase of temperature increases the solubility; thus potassium nitrate increases rapidly in solubility with increasing temperature, while common salt increases very slightly (*see* CURVE, *under* POTASSIUM COMPOUNDS), and sodium sulphate, Na_2SO_4, diminishes in solubility. Solutions of some solids can be prepared which contain more of the solid at a given temperature than the amount of the solvent present in the solution could be made to dissolve if solvent and solid are shaken together at this temperature, no matter how long the shaking is continued; such solutions are called supersaturated. Let 100 grams of water be boiled with sodium sulphate till it can take up no more of the salt; now filter into a perfectly clean flask, and plug the neck of the flask with cotton wool; even when the solution has cooled to 15°, no crystallisation will have occurred. If a crystal of sodium sulphate be dropped in, crystallisation begins at once, and the salt separates out with evolution of heat; when the system has cooled again to 15°, it will consist of sodium sulphate and a saturated solution of sodium sulphate. These supersaturated solutions differ in no way except stability from unsaturated solutions, and they are formed in virtue of what may be called phase inertia. When a substance undergoes solution, contraction usually occurs; that is, the volume of the solution is less than the sum of the volumes of substance dissolved and of the solvent used to dissolve it; also when a solution is diluted with more of the solvent, there is usually a contraction. If in making salt solutions, chemically equivalent quantities of salts are made up to the same volume, certain relations appear between the densities of the solutions. Suppose normal solutions are used and two bases are fixed on, say, potassium and ammonium, then whatever acid these bases are combined with, there will be a constant difference between the densities of the normal solutions KA and NH_4A, where A stands for the acid. A similar statement holds for acids. Therefore, by taking the densities of a comparatively few normal solutions of salts, it is possible to calculate the density of any normal solution. Example: The densities of normal ammonium and potassium chlorides are 1·0157 and 1·0444; the difference is 0·0287; the density of normal ammonium bromide is 1·052, or 0·0363 more than the chloride. Therefore the density of normal potassium bromide is (1·0157 + 0·0287 + 0·0363) = 1·0807, the actual value being 1·08. The density of normal ammonium chloride is taken as the standard, and the numbers added to it are *Valson's moduli* for potassium and bromine respectively. Substances soluble in water may be divided into two classes: (I.) Those that give solutions which conduct a current of electricity and are thereby decomposed: (II.) Those which do not conduct a current of electricity. Class I. is found to consist of acids, bases, and salts. The reason why members of this class conduct and are thereby decomposed is that they are resolved on solution into ions (*q.v.*), which under the influence of the current are driven, at speeds which for a given potential difference and temperature are characteristic for each ion, to the electrodes, and there give up their charges. The fate of the ion when it gives up its charge depends on the nature of the ion; if it is not readily attacked by the solvent, it will be deposited at the electrode as a solid, or will escape there as a gas; if it is attacked by the solvent, then chemical action will occur at the electrode. Example: When copper sulphate dissolves in water it decomposes in whole or part, according to the equation $CuSo_4 \rightleftarrows \overset{2+}{Cu} + \overset{2-}{SO_4}$. On sending the current through this solution undecomposed molecules take no part as carriers of the current; but the copper ions are driven to the negative electrode at a speed characteristic for them, and there they lose their charge, and are deposited as metallic copper, while the SO_4 ions are driven to the positive electrode at a speed characteristic for these and different from that of the copper ions, and at the electrode they are deprived of their charge; but the group SO_4 is not set free—it attacks the electrically neutral water molecule, setting free $2\overset{+}{H}$ and appropriating the charge on the oxygen which is liberated, and thus reproducing the SO_4 ion $\overset{2-}{SO_4}$; that is, sulphuric acid is formed at the anode. A salt or acid on solution does not always form simple ions; many irregularities in the conductivity for electricity of salt solutions are accounted for by the formation of complex ions; these complex ions are generally formed by the union of simple ions with undissociated molecules: for example, in the case of cobalt chloride at great dilution it ionises thus:

$CoCl_2 \rightleftarrows \overset{2+}{Co} + 2\overset{-}{Cl}$, but in strong solutions the actions

$$\overset{-}{Cl} + CoCl_2 = \overset{-}{CoCl_3} \text{ and } 2\overset{-}{Cl} + CoCl_2 = \overset{2-}{CoCl_4}$$

probably occur. As the ions are the carriers of the current, the conductivity (by conductivity may be understood molecular conductivity—that is, the reciprocal of the resistance, expressed in ohms, of a solution containing one gram molecule of the dissolved substance contained in a rectangular vessel, two opposite sides of which form the electrodes and are one centimetre apart, while the other sides are nonconductors; the temperature must be constant and specified) of a strong solution should increase on dilution to a maximum corresponding to complete ionisation, and this corresponds with observation. Another deduction to be drawn from the ionic view of solutions is that the ordinary reagents used in qualitative analysis are reagents for ions; when one tests for a chloride in a solution by means of a solution of silver nitrate, then one is really testing for chlorine ions; so that although potassium chloride and potassium chlorate each contain one atom of chlorine in the molecule, only the former will react with silver nitrate to form silver chloride, for these salts form ions in accordance with the equations

$$KCl \rightleftarrows \overset{+}{K} + \overset{-}{Cl} \text{ and } KClO_3 \rightleftarrows \overset{+}{K} + \overset{-}{ClO_3}.$$

It is clear that both salts will give the reactions for potassium. The law of mass action (*see* MASS ACTION) applies to a solution which contains undissociated molecules and ions. Suppose a solution of common salt is precipitated by an equivalent solution of silver nitrate, then we have the reaction

$$\overset{+}{Na} + \overset{-}{Cl} + \overset{+}{Ag} + \overset{-}{NO_3} = AgCl + \overset{+}{Na} + \overset{-}{NO_3};$$

but this is not all, for silver chloride is slightly soluble in water, so there will remain some silver and some chlorine ions not precipitated, and a few undissociated silver chloride molecules. Now these ions will be in equilibrium with undissociated silver chloride, and the latter will be kept at constant concentration by the precipitate; hence we must have (law of mass action) $pq = kr$, where p and q are the concentrations of the silver and chlorine ions, and r

that of the silver chloride; but kr is constant, and therefore pq must be constant; pq is called the SOLUBILITY PRODUCT in this case. If in the above case we desire to precipitate all the silver, or as nearly as possible all of it, then a *slight* excess of sodium chloride must be added so as to increase q; for in this case, as pq is to be constant, then as q is increased, p must be diminished—that is, a little more silver will be thrown out of solution. One more consequence of the ionisation theory may be given. If one and the same coloured ion be united to a number of different colourless ions to form salts, then these salt solutions at sufficient and equivalent dilution should show exactly the same absorption spectrum, namely, that of the coloured ion. Ostwald examined about 300 salts to test this deduction from the ionisation theory, and in every case found the theory confirmed; thus thirteen different permanganates all gave absolutely the same absorption spectrum. To Class II. belong mostly neutral substances such as sugars, and a very few salts such as mercury cyanide. The same idea of a resolution into parts of the molecules of acids, bases, and salts in solution is forced upon us by the phenomena of osmotic pressure (*q.v.*), and the correlated phenomena of lowering of the freezing point and raising of the boiling point of solutions. Suppose 342 grams of cane sugar are dissolved in water and made up to 22·22 litres, then at 0° this solution will have an osmotic pressure of 760 mm. of mercury; 342 is the molecular weight of cane sugar, and 22·22 is the number of litres occupied by 2 grams of hydrogen at 0° and 760 mm., and 2 is the molecular weight of hydrogen. It thus appears as if in a dilute solution of cane sugar the sugar molecules behave like gaseous molecules. Mercuric cyanide shows the same behaviour as cane sugar—that is, a solution containing one gram molecular weight of the salt (252 grams) in 22·22 litres, has at 0° an osmotic pressure of 760 mm. When the osmotic pressure of a solution of common salt is determined by the use of vegetable cells (*see* SEMI-PERMEABLE MEMBRANES), it is found that for a concentration corresponding to that of the sugar—one gram molecule in 22·22 litres—it is double the osmotic pressure of the sugar, thus indicating that each salt molecule is resolved into two particles, each behaving like a single molecule. All strongly dissociated binary electrolytes behave like sodium chloride; the particles into which the osmotic pressure observations indicate that they break up are ions. Substances like calcium chloride, which break up at great dilution into three ions—$CaCl_2 = \overset{2+}{Ca} + 2\overset{-}{Cl}$—have an osmotic pressure three times that of a cane sugar solution of like concentration. It will be seen that if osmotic pressures could be readily determined experimentally, that we should have a valuable means of finding molecular weights, for working at 0° with 2·222 litres of water containing a known weight of the substance the osmotic pressure would be found; it could then be calculated by simple proportion what amount of substance would give an osmotic pressure of 76 mm., and this would be one-tenth of the molecular weight. As this cannot be done, molecular weights are determined by observations of the lowering of the freezing point and raising of the boiling point of solutions. The connection between these and osmotic pressure has been determined both experimentally and theoretically. The experimental basis of the freezing point method is, in the case of aqueous solution: 1 gram molecule of a substance dissolved in a litre of water lowers the freezing point by 1·85°, if there is no dissociation. Boiling point determinations are made where water and a few other common solvents are not available and when a check is desired; ether is a common solvent in boiling point determinations, and for this solvent we have: 1 molecule of the substance dissolved in 99 molecules of ether raises the boiling point of the ether by 0·284°. For the practical method of freezing point determinations, *see* FREEZING POINT. SOLID SOLUTIONS: Examples of these are mixed crystals, such as are formed by crystallising mixed solutions of two isomorphous salts; a number of alloys, such as copper tin and iron carbon; glass of every kind. These are investigated chiefly by means of the Phase Rule. For further information on solutions—which is a huge subject—special works must be consulted, such as *The Theory of Solution* (Whetham), Van t'Hoff's *Lectures on Theoretical and Physical Chemistry*, and *Introduction to Physical Chemistry* (Walker). W. H. H.

Sonata (*Music*). A composition of from two to four different movements, generally three or four. The sonata may be said to have originated from the suite or partita, which were sets of dance tunes in one key, grouped together to form one complete piece. From the suites of Corelli and kindred musicians, composers led gradually to a more fixed key-tonality and showed the need of modulating and fixing the new key in the mind, and of closing the first section in that new key, and also of a greater balance between the two keys. Enlargement of each half of this first section and greater modulation followed, and a new subject was introduced with the new key. With Haydn and Mozart these characteristics are found firmly established, and two subjects, *i.e.* two distinct sets of themes or phrases, in related keys, appear. In their works they added to the three movements, *viz.* a quick, a slow, and another quick one, a fourth, consisting of the minuet and trio. This new movement was placed after the slow movement in the symphony. Beethoven found the sonata in a high state of perfection of design, and to it he added a still higher scheme of design and expression. The old unequal temperament was now dying fast and giving way to the new scale of twelve nearly equal semitones, and with this change came the enlargement of harmonic combinations and possibilities in the matter of modulations. Beethoven added the fourth movement of the symphony mentioned above to the sonata, afterwards altering the minuet to a Scherzo, which in form is the most free of all the sonata movements. He introduced also a much greater variety of key tonality, and bequeathed the sonata to us in that state of perfection which has served as the model down to the present time. Sonatas are compositions for one or two instruments; when for more than two they are called TRIOS, QUARTETS, etc., and if for an orchestra they are called SYMPHONIES, and the sonata form (*q.v.*) is more extended. The usual movements of the modern sonata are: (1) Allegro · (2) Slow; (3) Scherzo, or Minuet and Trio; (4) Rondo, or some other quick movement.

Sonata da Camera (*Music*). A chamber sonata; a secular sonata.

Sonata da Chiesa. A church sonata; a sonata for the organ.

Sonata Form (*Music*). The name given to the plan of design to which the first movement (at times other movements) of a sonata is generally written.

It is also known as First Movement Form; and as Binary Form, from its being in two parts. This form consists of the following:

First Part: "ENUNCIATION" or "EXPOSITION."

INTRODUCTION (optional).

PRINCIPAL SUBJECT in key of Tonic,

"BRIDGE" or Episode leading by modulation to the SECOND SUBJECT in key of Dominant or some other related key (should key of Principal Subject be minor, the Second Subject is generally in key of Relative major or sometimes Dominant minor).

A CODETTA in this new key ends first part with a double bar, either with or without repeat sign. The codetta is not invariably added.

Second Part: consisting of (*a*) DEVELOPMENT or FREE FANTASIA, (*b*) RECAPITULATION.

(*a*) WORKING OUT or developing of material in first part by numerous devices in various keys different from those used in the Enunciation, eventually leading back to

(*b*) RECAPITULATION of First Subject in key of Tonic,

"BRIDGE" or Episode leading away from and back again to key of Tonic.

SECOND SUBJECT in key of Tonic (when Second Subject in Enunciation is in Dominant minor, it is in Tonic major here).

A CODA is generally added to bring the whole to a close.

Sonometer (*Sound*). An instrument consisting of one or more wires or strings mounted on a base or sounding box so as to be capable of longitudinal vibration. Used for experiments on the pitch of notes and its relation to the length, mass, and tension of the vibrating strings.

Sonore, Sonoro (*Music*). Sonorous, resonant.

Soot. Unburnt carbon, from smoke; it also contains various other constituents (*e.g.* nitrogenous compounds) which render it valuable as a manure.

Sopra (*Music*). Above, before, *e.g. come sopra*, as before.

Soprano (*Music*). The highest of women's or boys' voices.

Soprano Clef (*Music*). The C clef on the first line. *See* STAVE.

Sopwith's Staff (*Surveying*). A staff used in levelling; its special feature is the clearness of the graduation, which enables it to be read at considerable distances through the telescope of a level.

Sordini (*Music*). Mutes; dampers. The mute has already been described under MUTE. It may be added that another method of muting brass instruments (as, for example, the horn) is by inserting the right hand into the "bell," thus three-quarters closing it. This, however, raises the sound half a tone, and necessitates transposing the music a semitone lower. In pianoforte music *con sordini*, with dampers, means that the right pedal is *not* to be used, and *senia sordini*, without dampers, that the right pedal *is* to be used. *See also* PIANOFORTE, p. 430, *and* UNA CORDA.

Sorting (*Textile Manufac.*) The operation of classifying the wool of the fleece according to quality and length of staple.

Sorts (*Typog.*) A term applied to the different letters in a case (*q.v.*)

Sostenuto (*Music*). Sustained; giving to each note its full value.

Sotto Voce (*Music*). Under the voice; in a somewhat hushed manner.

Sound. The study of phenomena which are detected by the sense of hearing, or which are of the same nature as these; the phenomena termed sounds are produced and transmitted by the vibrations of particles of matter. Sounds obey the ordinary laws governing the transmission of radiant energy in general; they can be reflected, refracted, etc.

—— (*Music.*) A musical sound is due to regular vibration. Its three qualities are: (1) intensity, due to the extent of the vibration; (2) pitch, due to the rapidity; (3) timbre, *i.e.* its quality, as distinguished from intensity and pitch, due to the form. Sounds are represented on paper by NOTES (*q.v.*) The length of a sound is shown by the shape of a note; the pitch of a sound by the position of the note on the staves.

Sound Board (*Music*). Another name for the belly in stringed instruments. *See* VIOLIN, p. 427. In the organ it is the upper part, or cover, of the wind chest. *See* ORGAN, p. 439. In the pianoforte it is the broad piece of wood under the strings and connected with them by the bridge, over which they are stretched. Its purpose is to reinforce the tone of the strings.

Sounder (*Elect.*) A telegraphic receiver capable of producing two distinct sounds by which the dot and dash of the Morse Code may be represented, the operator reading the message by ear. The sounds are produced by the armature of the electro-magnet in moving back and forth between its stops.

Sound Holes (*Music*). The two *f*-shaped openings in the belly or Sound Board (*q.v.*) of stringed instruments; they allow the belly to vibrate.

Sounding Board. *See* ABATVOIX.

Sound Post (*Music*). A wooden peg of pine which is placed a little behind the foot of the bridge on the treble side of stringed instruments. Its functions are to support the belly during the tension of the strings on the bridge, and to transmit the vibrations of the belly and bridge to the back of the instrument.

Sound, Velocity of. The velocity of sound in any medium is given by the general formula

$$\text{Velocity} = \sqrt{\frac{\text{Elasticity}}{\text{Density}}}$$

In the case of gases the adiabatic value of the elasticity must be taken. *See* ELASTICITY OF GASES. If v be the velocity in cms. per sec., P the pressure of the gas in dynes per sq. cm., γ the ratio of the specific heats of the gas, and ρ its density in grams per cubic cm., then

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Souple (*Silk Manufac.*) Silk from which about half the natural gum has been discharged, its weight being thus reduced by about $12\frac{1}{2}$ per cent. The dull appearance of raw silk is retained, but the hard feel removed. *Cf.* SOFT.

Sourdine (*Music*). (1) A stop on HARMONIUMS (*see* p. 443). (2) A MUTE (*q.v.*)

Souring (*Leather Manufac.*) The treatment of leather with acid, previous to dyeing or finishing, in order to bleach and cleanse the skin from stains. Souring with sulphuric acid has been proved to be very injurious. Latterly weak organic acids have been substituted.

—— (*Textiles, etc.*) Generically, the process of exposing textures to the action of dilute acid. In

the process of bleaching textile fibres or fabrics the goods are treated with a solution of chloride of lime and then with a dilute solution of sulphuric acid, which sets free the chlorine, bleaches the cloth, and also neutralises the alkalis.

South *or* **South Seeking Pole.** That pole of a magnet which points towards the South Pole of the earth when the magnet is freely suspended.

Southing (*Astron.*) The transit (*q.v.*) of a star or any other celestial body to the south of the zenith.

Sow (*Met.*) The main channel or receptacle through which molten iron flows from a melting furnace to the pig moulds. *See* FEEDER.

Space (*Music*). The alternate degrees of the stave between the lines are called spaces.

Space Box (*Typog.*) A small flat box or tray, divided into about six or eight compartments to contain the various spaces used in justifying lines of types. It serves a useful purpose in correcting matter.

Space Pass (*Textile Manufac.*) *See* ENTERING.

Spaces (*Typog.*) *See* TYPES.

Spall (*Build.*) A small chip off the edge of a stone.

Span. The width of an arch, girder, roof, etc., between the bearing surfaces. *See also* ARCH.

Spandrel *or* **Spandril** (*Architect.*) A triangular space such as the irregular triangular wall space which occurs between the outer mouldings of two adjacent arches and the horizontal line joining their highest points.

Spanish School of Painting. *See* PAINTING, SCHOOLS OF.

Spanner (*Eng.*) A tool used for turning nuts. The nut fits into a short slot, usually formed by two jaws, open at one end. In adjustable spanners the width of this slot can be varied to suit different sizes of nut. In some fixed spanners a hole the shape of the nut is provided, instead of a slot with parallel sides.

Spar (*Min.*) A miner's term for any glittering mineral; generally confined to those which are crystallised, but not necessarily to those which are white or colourless.

Spare Parts (*Eng., etc.*) Duplicates of those parts of a machine which are liable to injury or which quickly wear out are often supplied, especially in the case of machines which are used at some distance from a repairing shop.

Spar, Iceland (*Min.*) *See* CALCITE *and* ICELAND SPAR.

Spark (*Elect.*) The visible and usually audible phenomenon accompanying a sudden electric discharge.

Spark Arrester (*Eng.*) A perforated cap placed over the chimney of an engine used for agricultural purposes or in the neighbourhood of dry timber, etc., to prevent pieces of burning fuel from escaping.

Spark Gap (*Elect.*) A space between two terminals across which an electric spark passes.

Sparking of Dynamos, etc. (*Elect. Eng.*) The production of sparks at the tips of the brushes, due to defective design or incorrect adjustment of the brushes.

Spartalite (*Min.*) A synonym for Zincite (*q.v.*)

Spathic Iron Ore (*Min.*) A synonym for Chalybite (*q.v.*)

Spatula. An instrument shaped like a paper knife, paddle, spoon, or trowel, according to its purpose, and made of bone, metal, or other suitable material. Used by chemists, enamellers, sculptors, etc.

Spear (*Arms*). A weapon consisting of the characteristically shaped head attached to the end of a wooden shaft. Designed for thrusting and throwing. Spears were amongst the earliest of weapons, and were used notably by the ancient Greeks. *Cf.* JAVELIN *and* LANCE.

—— (*Mining*). A term applied to the vertical rods driving the pumps used for draining a mine.

Species (*Biol.*) A subdivision of a GENUS, including all the members of a group of individual organisms which have certain characters in common. "The members of a species are fertile *inter se*, but not usually with members of another species" (J. A. Thomson). *Cf.* GENUS *and* ORDER.

Specific Conductivity (*Elect.*) The reciprocal of the SPECIFIC RESISTANCE (*q.v.*)

Specific Gravity (*Phys.*) The ratio between the density of a body and the density of a substance chosen as a standard. The specific gravity of solids and liquids is given in terms of water. In this case the specific gravity is the ratio between the mass of any volume of the substance and the mass of an equal volume of water.

Specific Gravity Flask (*Phys.*) *See* PYKNOMETER.

Specific Heat (*Phys.*) The ratio between the quantity of heat necessary in order to raise a given mass of any substance through a given difference of temperature, and the quantity of heat necessary to raise the same mass of water through the identical difference of temperature, is the (average) specific heat of the substance between those temperatures. The specific heat may be more simply, though less accurately, expressed as the number of heat units required to raise unit mass of a substance through one degree.

Specific Heats of Gases (*Phys.*) The amount of heat necessary to raise unit mass of a gas through one degree depends upon the conditions under which the gas is heated. If the gas be not allowed to expand, the heat required to raise unit mass one degree is termed the SPECIFIC HEAT AT CONSTANT VOLUME; this is usually represented by C_v. If the gas be allowed to expand while being heated, then external work is done, and the specific heat is increased by the amount of heat which is equivalent to the external work performed. If the gas be allowed to expand while being heated, at such a rate that its pressure remains constant during the operation, the heat absorbed is termed the SPECIFIC HEAT AT CONSTANT PRESSURE; it may be denoted by C_p. The ratio of C_p to C_v depends on the nature of the molecule of the gas.

Specific Inductive Capacity (*Elect.*) The ratio between the capacity of a condenser, of which the plates are separated by a given medium (*e.g.* sulphur, mica, paraffin wax, etc.) and that of a condenser similar in form and dimensions, whose plates are separated by air, is termed the SPECIFIC INDUCTIVE CAPACITY of the medium, which is generally denoted

by K. The value for some common substances is as follows:

Ebonite	1·92
Paraffin wax	2·29
Sulphur	3·97
Mica	6·64
Glass.	6·5 to 7·5.

The value for gases is very nearly unity, but increases as the pressure of the gas is increased.

Specific Resistance (*Elect.*) If r be the resistance of a conductor of length l and cross section a, then

$$r = \sigma\frac{l}{a}$$

The quantity σ is termed the Specific Resistance of the material of which the conductor is made; it is the resistance which the conductor would have if its length and its cross section were both unity. The approximate value of σ for some common materials (taking the centimetre as the unit of length) is as follows:

Silver	1·5	microhms.
Copper	1·6	,,
Aluminium . . .	2·9	,,
Iron	9·6	,,
Lead	19·5	,,
Mercury	94	,,

Specific Volume (*Phys.*) The volume of unit mass of a substance, usually expressed in cubic centimetres per gram.

Specimen Bar (*Eng.*) A bar of metal prepared for testing in the testing machine.

Specimen Holder (*Eng.*) A form of clip by which the ends of a specimen are held in the testing machine.

Specimen Page (*Typog.*) When a new work is about to be put in hand it is customary for the printer to prepare and submit a proof or specimen, showing the proposed size of page, style of type, general arrangement, etc.

Spectra. *See* SPECTRUM *and* SPECTRUM ANALYSIS.

Spectre of the Brocken (*Meteorol.*) An optical effect. Travellers standing at sunrise on the summit of the Hartz mountains see a magnified image of their shadows thrown upon the mists or clouds by the sun at their backs.

Spectrograph (*Astron.*) A form of Spectroscope (*q.v.*) adapted for photographically recording spectra.

Spectroheliograph (*Astron.*) A form of instrument for photographing the sun in monochromatic light, or in light of any particular wave length.

Spectroscope (*Phys.*) An instrument for the production and examination of spectra. In a typical form the light which it is desired to examine is first formed into a parallel beam by the COLLIMATOR. This is a tube, carrying a lens at or near one end, and at the other, which is directed towards the source of light, an adjustable SLIT. The latter lies in the focal plane of the lens, so that light diverging from the opening emerges from the lens as a parallel beam, and then falls upon a Prism (or train of prisms) or upon a Diffraction Grating (*q.v.*) After passage through the prism, the light traverses a telescope placed so that the whole beam is received by its object glass; on looking into the telescope, the spectrum is seen. The telescope can be turned about a vertical axis passing through the centre of the table of the instrument, so that it can be adjusted to view the slit directly through the collimator when the prism is removed, or can be so placed as to observe any particular portion of the spectrum. A circular divided scale is attached to the stand, and a vernier is carried by the arm of the telescope, so that the angle of deviation of any given line in the spectroscope can be accurately measured. (If this divided scale is carried nearly, or completely, round the table of the instrument, the latter is usually termed a SPECTROMETER, and may be used for measurements other than those of a spectrum, *e.g.* for measuring the angles of a prism.)

A DIRECT VISION spectroscope is one in which the axis of the telescope is in the same straight line as the axis of the collimator; in this case the whole instrument may be contained in a single tube, without any stand or scale. It is necessary in this case to produce dispersion without deviation of the mean rays or axis of the beam of light; this may be accomplished by a suitable combination of prisms (*e.g.* three of crown glass and two of flint glass), or by a combination of a diffraction grating and a prism.

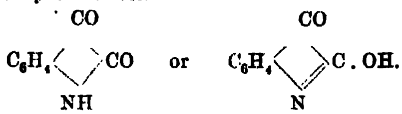
The relative positions of the lines of a spectrum may be observed in several ways. (1) The angular deviation of each line may be read off on the scale and vernier described above, a pair of cross wires in the eyepiece being brought into coincidence with each successive line. (2) A linear scale may be fitted so as to be viewed through the eyepiece simultaneously with the spectrum under observation and the positions of the lines relatively to the divisions of the scale noted. (3) The spectrum may be photographed by causing the beam to enter a suitable camera instead of observing the spectrum through the telescope.

Spectrum (*Phys.*) If a beam of white light be refracted through a prism and then received on a screen, it is seen to be drawn out (DISPERSED) into a brilliantly coloured band, which is termed a SPECTRUM. The colours merge gradually into each other, but it is easy to distinguish approximately seven regions whose colours are respectively Red, Orange, Yellow, Green, Blue, Indigo-blue, Violet. The deviation is least in the case of the red rays, and gradually increases as the violet is approached. Further investigation shows that the dispersion or separation of the constituents of the original light is not confined to the regions forming the VISIBLE SPECTRUM. There are present invisible rays which are less deviated than the red, and which are termed the INFRA-RED RAYS, and also others which are more deviated than the violet, termed the ULTRA-VIOLET RAYS. The former are most easily observed by their thermal effects, detected by a thermopile or bolometer; the latter by the aid of photography. The invisible parts of the spectrum which have thus been investigated are of much greater extent than the visible portion, extending from ultra-violet light of wave length about ·00001 cm. to nearly one hundred times that length; while the visible spectrum only includes light of wave length lying between ·00004 and ·00008 cm. If light of any particular wave length be absent from the original beam, a dark line appears in the spectrum. The solar spectrum contains a number of these dark lines, which are termed FRAUNHOFER LINES. A spectrum which is unbroken by lines is termed a CONTINUOUS SPECTRUM, as distinguished from a LINE SPECTRUM, in which they occur. A third type of spectrum is

termed a FLUTED SPECTRUM, in which a banded appearance is given by a number of fine lines arranged in groups. *See also* SPECTRUM ANALYSIS.

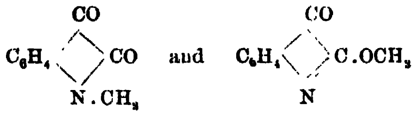
Spectrum Analysis (*Chem.*) The light emitted by an incandescent gas is characteristic for that gas: but the light must be examined in the spectroscope (*q.v.*), where it can be seen arranged in the order of the wave lengths of its component colours, that is, its spectrum (*q.v.*) must be seen. For example, if a sodium compound is put on a platinum wire, and held in a Bunsen flame, some of the compound is volatilised and decomposed, the sodium vapour emits a yellow light, and this, when viewed in the spectroscope, shows two yellow lines, very close together, of wave length 5,896 and 5,890. (The unit of length is 1×10^{-7} mm. = one tenmillionth of a millimetre, which is called the Ångström unit.) No element besides sodium gives this spectrum. The Bunsen flame has not the highest temperature that it is possible to command; both that of the electric spark and of the electric arc are higher. When a sodium compound is volatilised in either of these, it gives the two yellow lines mentioned above, and many other lines as well. Elements (for example platinum) which are not gasified in the Bunsen flame, and therefore give no spectrum, give spark and arc spectra. The spectrum of a gas is obtained by enclosing the gas in a glass tube, provided with two platinum electrodes, exhausting the tube to a suitable degree, and sending the current from an induction coil through the rarefied gas; the light examined in the spectroscope gives the spectrum of the gas. By one or other of these methods every element can be made to give a spectrum, and every element has its own spectrum, composed of light of wave lengths peculiar to that element. The spectra of all the elements have been "mapped," that is, the wave lengths of the lights they emit have been tabulated, for the Bunsen flame, the spark obtained from an induction coil with and without the use of Leyden jars, and for the arc. Should the spectrum of a supposed element be examined, it is possible to pick out some of the more prominent wave lengths in its spectrum, and compare them with those of all the known elements, and in this way to tell whether a known element is being dealt with. Thus, when the Curies were isolating radium, they submitted their preparations to an expert spectroscopist (Demarçay), and "the results of the spectrum analysis brought conviction to us when we were still in doubt as to the interpretation of the results of our research." The first new line found by Demarçay was 3814·7 (Å.u)—a line just in the ultra-violet. (N.B.—The extent of the spectrum visible to the eye is from about 6,500 in the red to 3,900 in the violet.) Many elements have been discovered by means of their spectra, *e.g.* Cæsium, Rubidium, Thallium, Indium, Gallium, and Helium. A compound of an element does not always give the spectrum of the element in the Bunsen flame; the compounds of the alkalis give the spectra of the alkaline metal, but compounds of the alkaline earths, calcium, strontium, barium, give spectra containing few lines of the metal and more of the compound employed, or the oxide of the metal. Flame spectra are best obtained from halogen salts of the metal: a non-volatile salt should be converted into chloride. In spark spectra the halogen salts give the metal lines. The number of lines in the spectra of the various elements varies enormously; for instance, from a dozen in lithium to about 4,500 in iron. The number varies also with the temperature, for while thallium gives one line in the Bunsen flame, it gives about 24 in the arc. Relationships are gradually being discovered between the lines of one and the same element, and between lines of chemically related elements. For example, a formula of the type $\frac{1}{\lambda} = A - Bn^{-2} - Cn^{-4}$, when the constants are properly chosen from a few lines, will give with more or less accuracy a fair proportion of the remaining lines. In the case of hydrogen the formula becomes $\frac{1}{\lambda} = A - 4Am^{-2}$, where $A = 27418{\cdot}75$, and m is in succession 3, 4, 5, etc., and it gives many of the lines very accurately. Again, in the case of many elements the lines fall into series, a principal series of sharp lines, a first and second subordinate series of less sharp lines. A modification of the typical formula has to be used for each series. The lines of a related series of elements are often related, *e.g.* the lines of sodium, potassium, rubidium, cæsium run in doublets, those of magnesium, zinc, cadmium run in triplets. In some cases it is possible to calculate approximately the atomic weight of an element in a related series, when the relations of the lines of the various series to the lines of the various series of its related elements have been established. When light passes through a substance, some of it is absorbed; if the substance exerts a SELECTIVE ABSORPTION for light of definite wave lengths, then the light transmitted will be characteristic, under proper conditions, for that substance, and an examination of the transmitted light in the spectroscope will show dark bands in its spectrum corresponding to the wave length of the light absorbed by the substance. The bands are called ABSORPTION BANDS, and their nature, position, and extent for a given thickness of the substance, serve to identify the substance. The dark lines in the solar spectrum are due to absorption. An incandescent gas absorbs precisely those rays which it emits at the same temperature (Kirchhoff). Thus, when a sodium compound is held on platinum wire in front of the slit of a spectroscope, the two yellow sodium lines are seen. Now if a strong white light is brought behind the sodium light, a continuous spectrum is seen, except for two dark lines, which cross it exactly where the two yellow lines were before. The vast number of dark lines which appear in the solar spectrum (Fraunhofer lines) are due chiefly to elements which exist in the atmosphere of incandescent gas which surrounds the sun and which exercises selective absorption on the rays of every wave length issuing from the incandescent mass of the sun below. The Fraunhofer lines are produced by about thirty-six elements, which occur on the earth. A few of the dark lines of the solar spectrum are due to the absorptive action of the earth's atmosphere. Some of the lines are due to oxygen and some to water vapour: a group of lines (5,860 to 6,030) near the sodium lines is due to water vapour, and when there is much water vapour in the air this group darkens, and is therefore used to predict rain, and has received the name of the RAIN BAND. Many coloured liquids show absorption bands, and many liquids which appear to us to be colourless show absorption bands in the ultra-violet, and would therefore be coloured to an eye sensitive to the ultra-violet. Most probably an ant would regard benzene as a coloured substance. Among substances which can be easily detected by their absorption spectra are blood (Hæmoglobin, oxyhæmoglobin, carboxyhæmoglobin), very many "aniline" dyes, ultra-

marine, and some precious stones. *See also under* SOLUTIONS. The absorption spectra of a number of tautomeric substances have been examined by Professor Hartley, and he has been able to throw light on the structure of some of these. Example, isatin may be written—



I. II.

It has two different methyl derivatives—



Methylpseudoisatin. Methylisatin.

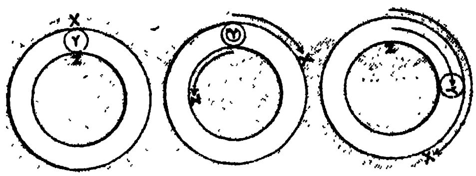
Now the spectra of isatin and methylpseudoisatin closely resemble each other, and both have two bands; the spectrum of methylisatin has a single, strong, absorption band. Hence of the two formulæ for isatin the one marked I. belongs to isatin—at all events in alcoholic solution, in which state the bands were observed. W. H. H.

Specular Iron (*Min.*) A synonym for the crystallised variety of HÆMATITE (*q.v.*), so called because the Roman ladies used the tabular crystals as mirrors.

Speculum. A mirror of polished metal, used by ancient races for the ordinary purposes of a mirror. Concave specula are used in reflecting telescopes. *See* TELESCOPE.

Speed. Velocity or rate of motion applied either to rectilinear or to rotary motion.

Speed Gears (Change) for Cycles. The influences adverse to a cyclist's progression fall under two heads:—I. *Mechanical:* (*a*) Vibration, caused by unevenness of the surface over which the cycle moves; (*b*) friction in the bearings of the machine. II. *Physical:* (*a*) Air pressure; (*b*) gravity. The first two of these have been lessened by the adoption of pneumatic tyres and ball bearings. The second group cannot be reduced, and the only way to minimise their effects on the rider is to use some mechanical device which shall enable him to avoid excessive exertion by sacrificing some speed. The cycle change-speed gears now on the market employ a "sun and planet" epicyclic train of cogwheels to reduce or increase the speed of the drive relative to the normal, or solid, gear. Usually the train is included in the hub of the driving wheel; in a few cases in the large chain sprocket wheel. James Watt is considered to be the inventor of the sun and planet motion, which he used on his steam engines to impart motion from a connecting rod to a flywheel. The "sun" was attached rigidly to the wheel spindle, the "planet" rigidly to the end of the connecting rod, and a bridle link, passing round the central bosses on each cog, kept the two pinions—which had an equal number of teeth—always in mesh. This ingenious contrivance not only transformed the linear movement of the piston rod into a rotatory movement of the flywheel, but also caused the "sun" and flywheel to turn *twice* on their centres while the "planet" circled the "sun" once, since the planet forced the sun to overrun it, as a little reflection will render apparent. In epicyclic cycle gears there is, besides the sun and planet, an exterior annulus with internal teeth, revolving concentrically with the sun. The planet rolls between the two.



SPEED GEARS.

From figs. *a*, *b*, and *c* the action of the train and the data for calculating speed ratios can be gathered. In the figures we have X the outer annulus, Y the rolling pinion or "planet," and Z the fixed pinion or "sun." To understand how this combination works, let us first suppose (fig. *b*) that the axis of the pinion Y is fixed in space, the pinion being, however, capable of rotating about this axis. Further, let us suppose that the "sun" Z and the annular rack X are perfectly free to rotate, and that the number of teeth on Z is t, while the number on X is T. Then if the pinion Y has n teeth, a complete clockwise revolution of Y about its stationary axis will cause n teeth to engage in succession with the teeth of X; and the annular rack will therefore advance by n teeth, or by $\frac{n}{T}$ of a complete rotation in a *clockwise* direction (fig. *b*). At the same time, n teeth of the inner pinion Z must have been engaged in succession, and Z must have rotated through $\frac{n}{t}$ of a complete rotation in an *anti-clockwise* direction. In fig. *c* the sun is stationary, and the axis of Y is free to move. Let us now suppose that the whole arrangement is rotated as a single body about the centre of Z through $\frac{n}{t}$ of a complete clockwise rotation; this will bring the central pinion Z to its original position. The axis of Y will have revolved about the centre of Z through $\frac{n}{t}$ of a complete clockwise revolution, and the rack X will have rotated about the centre of Z through the sum of the angular displacements imparted to it, *i.e.* through $\left(\frac{n}{t} + \frac{n}{T}\right)$ of a complete clockwise motion. Thus:

$$\frac{\text{Angular displacement of X}}{\text{Angular displacement of Y}} = \frac{\frac{n}{t} + \frac{n}{T}}{\frac{n}{t}} = \frac{t + T}{T}$$

From this it is clear that if the central pinion Z is maintained stationary while the annular rack is rotated at any given speed, the pinion Y being free to roll as the conditions require, then while Y rolls once completely round Z, the annular rack X will make $\frac{t+T}{T}$ rotations. Thus we have:

$$\frac{\text{Speed of rotation of X}}{\text{Speed of rotation of Y}} = \frac{t+T}{T}.$$

If the motion of Y is opposed by a given force, and a motive force acts on X, then:

$$\frac{\text{Force acting on X}}{\text{Force opposing motion of Y}} = \frac{T}{t+T}$$

To take an example: if X has fifty teeth and Z

twenty-five teeth, one revolution of the axis of Y about the centre of Z implies $\frac{50+25}{50} = 1\frac{1}{2}$ rotations of X, and, conversely, one rotation of $X = \frac{50}{50+25} = \frac{2}{3}$ revolution of Y. If a given motive force be applied to X, this will be capable of overcoming a force 50 per cent. greater opposing the motion of Y, and the speed of Y will be less than that of X by $33\frac{1}{3}$ per cent. If the force be applied to Y's centre, there will be a speed gain of 50 per cent., and a diminution of force of $33\frac{1}{3}$ per cent. with regard to X. Should X and Z be mechanically connected so as to form a rigid whole, Y obviously can no longer roll round Z. In general, if *any* two of the elements X, Y, and Z are rigidly connected, the combination can move only as a solid body. With a three-element epicyclic gear three gears are possible. The gear may: (1) turn as a whole: (2) it may be geared *up* by transmitting the rider's driving power through the small sprocket wheel to Y, from Y to X, and from X to the spokes of the driving wheel; (3) it may be geared *down* by transmitting the power to X, and through Y to the spokes. These three combinations give the normal, high, and low speeds respectively, as found in the "Sturmey-Archer" gear. In the "Fagan," "Hub," and other well-known gears only two combinations are used, the higher gear being the solid, since it is more generally used. Want of space forbids a detailed description of the methods by which the element Z is rendered fixed or movable, and two elements are locked together. It must suffice to glance at the "Fagan" gear, which has a sprocket working the driving annulus by a Hyde freewheel attachment. The annulus has sixty-four internal teeth, which gear with four planet pinions rotating on pins forming part of the hub shell. The central pinion has twenty teeth. When pulled in one direction along the spindle it is able to revolve freely; but if pressed by a spring in the other direction, engages with the internal teeth of a collar solid with the spindle. In this last position the central pinion is fixed, and the low gear is obtained. To throw in the high or solid gear, the rider, by means of a wire cable, pulls the central pinion free of the toothed collar, and brings it into engagement with teeth on the interior of a central opening in a plate cast solid with the annulus, causing annulus and "sun" to rotate together. With regard to the number of teeth on X, Y, and Z, the empirical rule has been established that the teeth on X must be equal to (teeth on Y × 2) + teeth on Z, whatever be the ratio of the gearing. If X remains constant in size, the difference of velocity of rotation of X and Y about the axis of Z will increase with the decrease in the diameter of Y and the increase in the diameter of Z. As X must be kept conveniently small, and Z yet be sufficiently large to slide on the back wheel spindle, the size of Y relative to that of Z is confined within somewhat narrow bounds; and in most popular two-speed gears a drop of 20 to 25 per cent. from the solid to the low gear is usual. As cycle change-speed gears give only a limited number of ratios, they are compromises which naturally incur criticism. The best proof of the utility of this class of mechanism is found in their increasing adoption by the cycling public. A. W.

Speed Indicator. An instrument for indicating or recording rate of motion, whether motion of translation or of rotation.

Speed of Ignition. The rate at which the explosion or burning of the mixture of inflammable gases occurs in the cylinder of a gas or oil engine.

Speed of Reactions (*Chem.*) Let there be two substances, A and B, which react to form two new substances, A^1 and B^1, and let the substances A^1 and B^1 be capable of reacting so as to reproduce A and B; further, let A and B react molecule for molecule with each other, and A^1 and B^1 react in the same way: then if the system is homogeneous, and p, q, p^1, q^1 are the concentrations of A, B, A^1, B^1 respectively, we have, by the law of mass action (*see* MASS ACTION), for equilibrium, $kpq = k^1p^1q^1$. This implies that the two reactions, the direct and the reverse, are proceeding at the same speed. At a particular moment before equilibrium is reached, the speed will be given by the difference between the speeds of the direct reaction and the reverse reaction; so that if a, β, a^1, β^1 are the concentrations at the beginning of a definite time, and a quantity x gram molecules is transformed in time t, then

$$\frac{dx}{dt} = k(a-x)(\beta-x) - k^1(a^1-x)(\beta^1-x).$$

Now suppose that the reverse reaction occurs to an extent which is inappreciable, the equation becomes

$$-\frac{dx}{dt} = k(a-x)(\beta-x).$$

Put $a - x = C$, and $\beta - x = C^1$, then

$$(1) \quad -\frac{dC}{dt} = kCC^1.$$

If only one substance is present, we shall have

$$(2) \quad -\frac{dC}{dt} = kC.$$

The minus sign occurs because the concentration diminishes while the time increases. Equation (2) gives the speed of a monomolecular reaction, that is, a reaction in which single molecules decompose; equation (1) gives the speed of a bimolecular reaction, that is, one in which two substances react molecule for molecule with each other. More complex reactions are not considered in this article. In the monomolecular reaction, let the concentration at the beginning be C_0, and at the end of a time t, C_t; then on integrating between these limits we get—

$$\log_e C_0 - \log_e C_t = kt.$$

Or, taking logarithms to base 10—

$$\log C_0 - \log C_t = 0{\cdot}4343kt.$$

From this it is seen that $C_t = 0$ when t is infinite, that is, a reaction never comes to an end in a finite time. In practice a reaction is at an end when the concentration of the substance which has undergone change is so small that our tests for its presence fail. As an illustration of a monomolecular reaction, the inversion of cane sugar by a dilute acid may be given—

$$C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6.$$

Here the water which enters into the reaction is so small compared with the whole amount present that it may be neglected, in which case we have a monomolecular reaction. The progress of the reaction can be determined by a polarimeter. Wilhelmy first made this experiment (1850), and he showed that the value of $\frac{\log C_0 - \log C_t}{t}$ was constant within the limits of experimental error during the whole course of the experiment. Another example of this kind of reaction which has been carefully studied and shown to conform to the equation is the decomposition of arseniuretted hydrogen by heat

$AsH_3 = As + 3H$. In the case of the bimolecular reaction we shall assume that the concentrations of the two substances are the same; then, on integrating equation (1) between the same limits as before, we have—

$$\frac{1}{C_t} - \frac{1}{C_0} = C_0 kt.$$

A very important example of this kind of action is the saponification of an ester by an alkali. The case of ethyl acetate and caustic potash in twentieth normal solutions has been thoroughly examined, and in this case $\left(\frac{1}{C_t} - \frac{1}{C_0}\right)\frac{1}{t}$ was again found to be constant. Many factors influence the speed of reactions. Temperature has an enormous influence. Thus in the case of the monomolecular reaction

$$\begin{array}{ccc} CHBrCOOH & & CH.COOH \\ | & = & \| \\ CHBrCOOH & & CBr.COOH \\ \text{Dibromsuccinic Acid.} & & \text{Brommaleic Acid.} \end{array} + HBr$$

which occurs in aqueous solution, a rise of temperature of 86° (15° to 101°) increases the speed over 3,000 times. The solvent has also a great influence; ammonium cyanate is transformed to urea much quicker in an alcoholic than in an aqueous solution. The presence of a third substance has often a very great influence; this kind of influence is called catalytic action, and examples are very numerous. Thus, water in small traces causes many substances to combine which will not combine in its total absence, as oxygen and hydrogen, chlorine and hydrogen, etc., and it causes substances to dissociate which will not dissociate when absolutely dry, as ammonium chloride and mercurous chloride. Platinum black (*see* PLATINUM), enzymes (*q.v.*), are other examples of catalytic agents. Pressure exerts a considerable influence on many reactions; it retards the inversion of cane sugar by hydrochloric acid, but it accelerates the hydrolysis of methyl acetate by the same acid. Diminution of pressure accelerates the oxidation of phosphorus by oxygen. *See also* EXPLOSIVES. W. H. H.

Speed Pulleys *or* **Cones** (*Eng.*) When a machine has to be driven at various speeds, it is commonly provided with a Speed Pulley or Stepped Pulley, which virtually consists of three or four pulleys of different diameters, fixed together to form a stepped cone, and keyed on the shaft. This pulley is driven by a belt from a pulley on the counter shaft, which is of similar construction, but arranged so that its widest end is opposite to the narrowest end of the pulley on the machine. In order that the belt may run properly when placed on any pair of pulleys, the sum of the diameters of the two pulleys must be a constant for each pair. If the belt be crossed its tension will then be perfectly constant, whichever pair it be placed on; it remains approximately constant, however, even if not crossed, provided the two pulleys are not too close together.

Spelter (*Met.*) (1) Ingots of zinc. (2) An alloy of copper and zinc, used in brazing.

Spent Oxide. *See* COAL GAS *and* SULPHURIC ACID MANUFACTURE.

Spermaceti. This is perhaps best described as "whale oil stearine," as considerable quantities are obtained from blubber and sperm oils by chilling and expressing, in the same way as stearine (*q.v.*) is obtained. Chemically, it is essentially cetyl palmitate. The name itself is misleading, as it was originally thought to be whale spawn, and thus was named *Sperma ceti*. The chief source is the "head matter" of the *Physeter macrocephalus*, but it is also obtained from the oils of many other cetacea. After "bagging" and pressing to separate the fluid oils the sperm cake is melted, re-pressed, and refined with a potash ley to remove colouring matter and free fatty acids, yielding a white glistening mass with a melting point of about 45° C. The product from the blubber oils of the bottlenose whale has a somewhat higher melting point. It is largely used in pharmacy as an unguent. It formerly was used in candle making and some soaps.

Spessartite (*Min.*) A manganese aluminium garnet, $6MnO, 3SiO_2 + 2Al_2O_3, 3SiO_2$; cubic. Commonly in dodecahedrons; deep brown red in colour. It imparts important cutting properties to some stones used for tool sharpening. From the Hartz, Sweden, Bavaria, and Piedmont.

Spewing (*Build., etc.*) When gravel, broken stones, etc., have been laid on a soft, wet surface (*e.g.* clay or mud), a quantity of mud is often forced out between the interstices. This is termed SPEWING. It is avoided by first forming a layer of coarse broken stone or "hard core" on the soft surface, and laying the gravel on this.

—— (*Leather Manufac.*) An exudation of oil from curried leather consisting of fatty matters which have failed to combine with the skin fibres, possibly on account of oxidation.

Sp. Gr. The contraction for SPECIFIC GRAVITY (*q.v.*)

Sphalerite (*Min.*) *See* ZINC BLENDE.

Sphene (*Min.*) Calcium titano-silicate, $CaO.TiO_2SiO_2$. Calcium oxide = 24·2, titanic acid = 43·2, silica = 32·5 per cent. Monosymmetric; usually brown and lustrous; rarely green. It is a common constituent of metamorphic rocks. It is found in the Criffel granite; in Argyllshire in schists; in Devonshire, France, Norway, etc.

Sphere. A surface of which all points are equidistant from a given point, termed the CENTRE of the sphere. A DIAMETER is a straight line passing through the centre and terminated at each end by the surface; a RADIUS, a straight line from the centre to the surface. Every plane section of a sphere is a circle; if the plane pass through the centre of the sphere, the circle is termed a GREAT CIRCLE; any plane not passing through the centre produces a SMALL CIRCLE. The AXIS of a great or small circle is the diameter of the sphere at right angles to the circle; the POLES of the circle are the ends of this diameter. Great circles passing through the poles are termed SECONDARIES to the circle. The part of the surface lying between three arcs of great circles is termed a SPHERICAL TRIANGLE. The area of a sphere of radius r is $4\pi r^2$; the volume is $\frac{4}{3}\pi r^3$.

Spherical Aberration (*Phys.*) A pencil of parallel rays after reflection from a curved mirror, or refraction through a lens, does not in general converge to (or diverge from) a single point. (*See* FOCUS, *etc.*) This departure from the elementary law is termed SPHERICAL ABERRATION.

Spherical Candle Power (*Light*). The average of the values of the candle power of a source of light, measured in all directions, *i.e.* at every point on the surface of a sphere surrounding the source. It is equal to the candle power which a theoretical point source, emitting light with uniform intensity in all directions, must possess in order that it may

emit the same total quantity of light as the source under consideration.

Spherical Excess (*Surveying*). Denotes the error due to the curvature of the earth's surface in a survey of great extent.

Spherical Triangle (*Geom.*) A part of a spherical surface intercepted between three arcs of great circles which intersect each other.

Spheroidal State (*Phys.*) If a small quantity of liquid be placed on a surface heated to a temperature considerably above the boiling point of the liquid it will collect into globules which roll about without boiling. A layer of vapour is formed between the drop and the hot surface.

Spheroidal Structure (*Geol.*) Artificial glass, if permitted to cool very slowly, tends to lose its transparency at many points throughout the mass; and when the glass has finally cooled, these semi-opaque areas are seen to be spheroidal in form, and to be made up of needlelike particles radiating from the centre of the spheroid. Recent investigations have proved that these needles consist of wollastonite, a silicate of lime. Many natural glasses and slags of eruptive origin show a similar structure, and to these the above name is given.

Spherometer (*Phys., etc.*) An instrument for measuring the radius of a spherical surface. It has three equidistant fixed pointed feet, which rest on the surface; in the centre is a screw with a pointed end, which can be raised or lowered by turning a graduated head fixed to the screw. The instrument is first placed on a plane surface, and the screw turned until its point exactly touches the surface: it is then transferred to the spherical surface and the screw raised (or lowered) until it again touches. If a be the distance through which the screw has been raised or lowered, and l the distance between the fixed points, the radius of the surface R is given by the formula

$$R = \frac{l^2}{6a} + \frac{a}{2}$$

Spherulitic Structure (*Geol.*) The term applied to the ball-shaped masses which many eruptive rocks, especially those of basic composition, are apt to assume after they have been exposed for some time to the weather.

Sphyrelaton (*Archæol.*) The name given to ancient hammered metal work.

Spider (*Elect. Eng.*) The part of an armature by which the core discs are supported and connected to the shaft; usually furnished with arms corresponding to the spokes of a wheel.

Spider Wheel (*Eng.*) Any wheel with very light radial arms.

Spiegel *or* **Spiegeleisen** (*Met.*) A pig iron or white cast iron containing 3·5 to 6 per cent. of carbon, and from 2 to 12 per cent. of manganese. Its fracture often presents well developed crystalline planes, hence the name. If the manganese is much in excess of the latter amount, the name FERRO-MANGANESE (*q.v.*) is given to the alloy. Spiegel is much used in steel manufacture as a convenient means of adding additional carbon, etc., to iron which has been almost entirely decarburised, as in the Bessemer, the Siemens, or the Siemens-Martin process (*q.v.*)

Spigot. (1) The end of a pipe that fits into the faucet or socket of another pipe. (2) A pin or small plug used to stop a faucet (*q.v.*) or a hole in a cask.

Spike (*Eng.*) (1) A large nail. (2) The fastening, resembling a nail, used to fix railway chairs (*q.v.*) to the sleepers.

Spile (*Carp. and Join.*) A rod of wood provided with a notch in the side, in which a pencil is held; it is used in marking the contour of an irregular surface or edge to which another piece of wood has to be fitted. The end or point of the spile is applied to the surface at a suitable point, and a mark made by the pencil on a board held in a convenient position; this process is repeated at a series of points along the irregular surface until a sufficient number of marks have been made on the board to enable the true contour of the given surface to be drawn.

Spiling (*Carp.*) The method of scribing with a SPILE (*q.v.*)

Spills (*Met.*) Openings or crevices found in inferior wrought iron bars.

Spinæ (*Music*). The name given to the jacks or plectra of the spinet.

Spindle (*Eng.*) A small axle or shaft.

—— (*Textile Manufac.*) (1) A common term for anything which rotates for the purpose of winding thread into coils, on to bobbins, or on a bare spindle. (2) An iron rod on which a tube or bobbin holding the spun yarn is placed.

Spindles (*Met.*) *See* BREAKING PIECES.

Spindle Tree (*Botany*). *See* EUONYMUS.

Spindle Valve (*Eng.*) A valve whose motion is guided by a rod fixed to the movable portion and running through bearings.

Spinel (*Min.*) Magnesium aluminium oxide, $MgO.Al_2O_3$. The chief mineralogical varieties are: (1) Ordinary, (2) Ruby Spinel, (3) Ceylonite, (4) Chlorospinel, (5) Picotite. Varieties named from colour are: Red, Spinel Ruby; Rose, Balas Ruby; Black, Pleonaste; Orange, Red Rubicelle; Violet, Almandine Ruby. Spinel crystallises in the cubic system, usually in octahedra. It is distinguished from the true or Oriental ruby by its inferior hardness, different crystalline form, and slightly inferior density; from garnet by its infusibility; from zircon by its lesser density. It is largely used as a gem. *See* PRECIOUS STONES. It is found in metamorphic rocks in Ceylon, Pegu, Siam, New Jersey, etc., and elsewhere in rocks of eruptive origin.

Spinel Ruby (*Min.*) A variety of SPINEL (*q.v.*)

Spinet (*Music*). A keyed instrument, varying in shape, played by means of jacks, and having one string to each note. The strings ran from left to right of the performer. In the Victoria and Albert Museum, South Kensington, may be seen various specimens of the spinet, as well as a clavicymbalo, an instrument with four strings to each note, two giving 8 ft. tone and the others 4 and 16 ft. tone respectively, which were also played by jacks. The spinet was in use in the sixteenth, seventeenth, and eighteenth centuries. *See also* MUSICAL INSTRUMENTS, p. 429, and VIRGINAL.

Spinning. *See* COTTON, LINEN, SILK, WOOL, MULE, RING FRAME, ROVE, SLIVER, SLUBBING, SPINNING JENNY, YARN, *etc.*

Spinning Jenny (*Cotton Manufac.*) The first machine by which the modern system of mechanically spinning cotton into yarns was effected. Invented by Hargreaves of Blackburn (Lancashire). In this machine the necessary degree of fineness

was imparted to the rovings by drawing them through "cloves," or clasp rods, instead of, as at the present time, by passing between rollers. It formed the nucleus of the subsequent inventions of Arkwright's water frame and Crompton's mills.

Spinning Metal (*Eng.*) The formation of circular objects from thin sheet metal in a lathe. The sheet metal is placed in front of a mould attached to the mandrel, and pressed into the mould as it revolves by a suitable tool. The latter resembles a burnishing tool, and has a rounded end, which is kept lubricated. Pewter and similar alloys can be *spun* very easily, but brass and copper can be treated in the same way if they are well annealed. Such objects as plates, cups and bowls, etc., are thus produced.

Spiral. A spiral is a plane curve, generated by a point which travels along a line while the latter rotates round a fixed point termed the POLE; the velocity of the moving point along the line (or RADIUS VECTOR) is related to the angular velocity of the latter by a definite law which determines the form of the spiral. Let r be the distance of the generating point from the pole, and θ the angle through which the radius vector has turned from some given position; then

for the SPIRAL OF ARCHIMEDES, $r = a\theta$;

for the LOGARITHMIC SPIRAL, $r = a\epsilon^{b\theta}$;

for the HYPERBOLIC SPIRAL, $r\theta = a$.

Spiral Gear (*Eng.*) Worm wheels, helical gear wheels, etc. (*q.v.*)

Spiral Nebulæ (*Astron.*) Nebulæ take various forms, among which a great number are spiral shaped. The nebula of Andromeda is the easiest to observe.

Spiral Spring. Strictly speaking, a spring coiled in one plane, such as a watch spring. But the term is also commonly applied to a HELICAL SPRING (*q.v.*)

Spire (*Architect.*) The tapering part of a steeple rising above the tower, forming a roof of very acute pitch. It is one of the characteristic features of Gothic architecture. *See* FLÈCHE *and* BROACH.

Spirillum (*Biol.*) Bacteria having the form of long unjointed threads, coiled into a spiral form.

Spirit. A term which includes METHYLATED SPIRIT, RECTIFIED SPIRIT, *and* SPIRITS OF WINE (*q.v.*)

Spirit Fresco. *See* PAINTING (METHODS).

Spiriting Off. *See* FRENCH POLISHING.

Spirit Level. A device for detecting deviations from a horizontal position. It consists essentially of a glass tube (or other suitable receptacle) containing spirit in which is a bubble of air; this bubble always moves towards the highest point in the tube, so that if one end of the tube be higher than the other the bubble moves to that end. The glass tube is attached to a suitable base, usually of wood.

Spirit, Motor. A mixture of the lighter petroleum hydrocarbons, having a specific gravity of 0·68 to 0·7. The test of gravity alone is an insufficient guide to the value of a spirit as a motor fuel. The chief characteristics to be noted are: (1) total range of vaporisation, (2) percentage volatile at 212° F. In (1) there is a guide to homogeneity, and a good spirit should have a range of 65° to 77° between the temperature at which it first gives vapour and the temperature at which it is wholly vaporised. In the case of (2) as much as 90 to 95 per cent. should be volatile at the temperature of boiling water (212° F.) Some spirits are as low as 81 per cent. No. 2 is an index to easy "starting up." This is *data* which can be easily supplied by any motor spirit maker, and will be found most instructive to the motor builder in determining the fuel best suited to his engine, as well as to the motorist in comparing the relative cost and efficiency of motor spirits.

Spirito, Con; Spiritoso (*Music*). With spirit; in a lively manner.

Spirit of Hartshorn (*Chem.*) (1) A solution of carbonate of ammonia distilled from Hartshorn. (2) At present it is generally the ordinary ammonia of the British Pharmacopeia (10 per cent. by weight NH_3).

Spirit Oil. A pale yellow light distillate that is sometimes obtained in the distillation of Yorkshire grease before the "first distilled grease" begins to run. It darkens on exposure to the air, and much resembles the distillate from bone tar. It boils at 150° C.

Spirits of Salts. A trade name for HYDROCHLORIC ACID (*q.v.*)

Spirit Varnish. *See* VARNISHES *and* FRENCH POLISHING.

Spitz-flöte (*Music*). A conical wooden organ pipe of thin, reedy tone. It is generally of 4 ft. tone, though it may also be of 8 or 2 ft. tone. Its name means "pointed flute."

Splashing (*Plumb.*) Placing melted solder on a joint that is to be wiped (*q.v.*) by throwing or splashing it from a ladle.

Splay (*Build.*) A sloping surface, larger than a chamfer; a surface making an oblique angle with another surface. To "splay" is to form such a surface on any object or part of a building.

Splayed (*Build.*) *See* SPLAY.

Spleen (*Zool.*) A spongy glandular organ forming one of the "ductless glands" found in vertebrates. It lies in the upper part of the abdomen, near the stomach, and has functions concerned with the blood corpuscles.

Splice. (1) A joint formed in timber by lapping the ends of two pieces together; sometimes used as synonymous with SCARF. (2) A joint in a rope, etc.

Spline. (1) A projecting ridge on a shaft, serving as a fixed key (*q.v.*) for a pulley, etc. (2) A thin lath or rod, usually of lancewood, used to aid the drawing of smooth curves through a number of given points.

Split (*Leather Manufac.*) A skin that has been split into two layers by a cutting machine. *Cf.* HAIR SPLIT *and* FLESH SPLIT.

—— (*Textile Manufac.*) *See* REED.

Split Bend (*Plumb.*) A bend in a pipe, made in two pieces.

Split Phase (*Elect. Eng.*) The division of an alternating current into two parts, differing in phase, is termed SPLITTING THE PHASE. If the current be divided into two branches in parallel with each other, one of these having a large resistance, the other a large self induction, the difference of phase will approach the maximum value, 90°. The device is commonly used in starting single phase motors. *See* MOTORS, ELECTRIC.

Split Pin. Usually made from a length of wire of hemispherical section, which is bent round until the flat sides are in contact, a small loop or head being formed at the bent end. The split end is passed through a hole in a rod or shaft, and the ends separated. The loop and the separated ends thus serve to retain some object in place.

Split Pulley (*Eng.*) A pulley made in two halves, which are placed in position on a shaft and then bolted together. By this means a pulley can be fixed on a shaft already in place without removing it from its bearings.

Split Ring (*Eng.*) A PISTON RING (*q.v.*)

Splitting (*Foundry*). Dividing a mould into two by means of a flat iron plate, termed a SPLITTING PLATE, in order to obtain a casting in two halves; the method is employed in casting split pulleys (*q.v.*)

—— (*Leather Manufac.*) The process of splitting leather into two or more layers parallel with the surface. *Cf.* CHAMOIS LEATHER.

Splitting Plate (*Foundry*). *See* SPLITTING.

Split Wheel (*Eng.*) Any wheel divided in two, as in the case of a SPLIT PULLEY (*q.v.*)

Spodumene (*Min.*) Aluminium lithium silicate, $Al_2O_3 . Li_2O . 4SiO_2$. Alumina = 29·4, lithia = 6·4, silica = 64·2 per cent. Monosymmetric. Grey or greenish, with very perfect cleavage parallel to the orthopinacoid. In the Peterhead granite, from co. Dublin, Sweden, Tyrol, the United States, etc.

Spoilage (*Print.*) The "waste" or spoiled sheets in printing.

Spoke Machine (*Eng., etc.*) A form of copying lathe used for making wooden spokes for wheels The piece of wood revolves in the lathe, and the tool moves backwards and forwards at right angles to the axis of rotation, being guided by an iron template of suitable form.

Spokes. The arms of a wheel.

Spokeshave (*Carp., etc.*) A tool consisting of a cutting iron of which the action is similar to that of a plane, but it is mounted in a stock or holder whose principal length is parallel to the cutting edge; the ends of the stock are formed into two handles by which the tool is moved backward and forward. Spokeshaves are chiefly used on work which possesses a considerable curvature, *e.g.* handrails, etc.

Sponge (*Met.*) A mass of iron from the puddling furnace not yet hammered into a homogeneous mass.

—— (*Zool.*) Sponges form a lowly division of the animal kingdom, coming just above the Protozoa, or simplest animals. They are marine animals, sedentary and passive like plants, with which they were once classified. They possess a skeleton formed of calcareous or siliceous spicules, or of fibres of a material termed SPONGIN, which resembles silk in its chemical composition. Both spicules and spongin fibres may occur in the skeleton. The sponge of commerce is the dried skeleton.

Sponge Bed (*Geol.*) In the Cretaceous Rocks, fossil sponges occur in abundance, and in some cases are sufficiently numerous to form beds of rock, which are termed Sponge Beds.

Sponge Cloth (*Eng.*) A cloth of loose texture used in place of cotton waste for wiping oil off machinery.

Spontaneous Combustion. Combustion produced without the application of heat from an external source.

Spoon Bit (*Carp.*) A form of wood boring bit somewhat resembling a small gouge, but having its cutting edge curved in profile.

Spoon Gouge. A gouge (*q.v.*) with a bent blade for cutting out cavities with curved internal surfaces.

Spot Cotton (*Cotton Trade*). Actual cotton bought for cash through a broker for immediate use at mill. *Cf.* FUTURES COTTON.

Spotting Motion (*Textile Manufac.*) A motion on the twisting frame for developing spots, at intervals, on the surface of twist yarns.

Spouts (*Meteorol.*) Cloud-like or fog-like phenomena of a slender and more or less tapering form formed in the air under certain atmospheric conditions. The more common form is a waterspout (*q.v.*)

Spray (*Foundry*). A small GATE or RUNNER (*q.v.*)

Spray Carburetter (*Motor Cars, etc.*) A spray carburetter consists of a small chamber, into which the liquid fuel (oil, spirit, etc.) used for driving a petrol or similar motor is converted into vapour and mixed with air to form an explosive mixture. The liquid enters the chamber through a small orifice which communicates by means of a tube of small bore with the tank in which the oil or spirit is stored; the supply of liquid is usually governed by a needle-valve actuated by a hollow metal float, which closes the opening when the liquid enters too rapidly. The stream of liquid being very fine quickly breaks up into fine drops, which rapidly vaporise in the chamber; the vapour mingles with air, and is drawn into the cylinder of the engine. *See* PETROL ENGINE. MOTOR CARS, CYCLES, *etc.*

Spray Tuyère (*Met., etc.*) A TUYÈRE (*q.v.*) cooled by water impinging on its surface in the form of very fine jets or spray.

Spreading Power of Pigments. *See* COVERING POWER.

Sprengel Pump. *See* AIR PUMPS.

Sprig. A brad or nail cut out of sheet metal.

Sprigging (*Carp., etc.*) To fasten with sprigs.

—— (*Foundry*). Supporting small and weak portions of a mould by means of thin sprigs or brads which are driven into the sand.

Spring (*Eng., etc.*) A piece of elastic material (tempered steel, hard brass, wood, rubber, etc.), generally in the form of a thin rod or ribbon, employed to exert a force in a definite direction when bent or otherwise distorted. This force may be required to actuate mechanism as in clockwork, to diminish the effect of sudden shocks, as in vehicles, or to exert some controlling effect on a moving part in certain mechanism. *See also* HELICAL *and* SPIRAL SPRINGS.

—— *or* **Springing** (*Architect.*) The point where the curved portion of an arch meets the abutments or piers. *See* ARCH.

Spring Balance. A device consisting essentially of a helical spring, whose extension is proportional to the weight or other force applied to it; the amount of this force is ascertained by reading off the extension of the spring on a properly divided scale which is attached to it.

Spring Bows. Small compasses whose legs are connected by a flat steel ribbon forming a spring, instead of by means of a hinge. The distance apart of the points can be regulated by means of a screw and nut.

Spring Chuck (*Eng.*) A chuck (*q.v.*) in the form of a hollow cylinder or cup, with several fine slits cut parallel to the axis. An object which is placed in a chuck of suitable size can be held fast by the pressure of the sides of the chuck, aided, if necessary, by a ring driven on to the outside of the chuck (which is turned to a slight taper). These chucks are only suitable for light work, but are very convenient when a considerable number of objects the same size are being turned up.

Spring Dividers. DIVIDERS (*q.v.*) with a spring joint similar to that of SPRING BOWS (*q.v.*)

Springer (*Build., etc.*) The stone abutment at the springing of an arch. *See* ARCH.

Springing Line. *See* ARCH.

Spring Jack. An interceptor used in curtain manufacture, so formed that it has sufficient elasticity to place itself in action upon the release of a string.

Spring Pawl (*Eng.*) A pawl or catch of a ratchet wheel which is caused to fall into its place by means of a spring.

Spring Ponty (*Glass Manufac.*) A tube of iron having a flat circular plate attached at one end. A light rod of iron running down the centre of the tube has a plate at its end in the form of a horseshoe. By means of a spring, the plate attached to the tube is made to press against the horseshoe plate. The foot of a wineglass is placed between these, and held in position by the spring. This allows the workman to finish the article the same as if it were *stuck* to the ordinary ponty.

Spring Pulley (*Eng.*) A pulley made of wrought iron or steel, divided by a cut passing through the boss and one side of the rim. It can be sprung open sufficiently far to enable it to be passed over a shaft, thus serving the same purpose as a true SPLIT PULLEY (*q.v.*)

Spring Ring (*Eng.*) A PISTON RING (*q.v.*)

Spring Safety Valve (*Eng.*) A SAFETY VALVE (*q.v.*) which is closed by a spring instead of a weight. The force acting on the valve is independent of the position or motion of the valve, and therefore a spring safety valve is suitable for locomotive or marine boilers.

Spring Tides (*Astron.*) *See* TIDES.

Spring Tool (*Eng.*) A metal turning tool which has a bend in its shank near the point. This enables the tool to yield or spring to a slight extent. It is used for taking a very light finishing cut on a piece of work which has been turned to very nearly its exact size.

Spring Water. *See* SPRINGS; WATER; *and under* SANITATION.

Springs. The overflow of the ground water. The rain, falling on a permeable stratum, percolates downwards until it reaches an impermeable stratum, and it is this underground store which crops up and forms springs. Various conditions determine the amount of rain which penetrates the ground, namely, the nature of the soil, the configuration of the land, the temperature and the movement of the air. Clay is almost impermeable, whilst gravel or a loose sandy soil absorbs about 96 per cent., limestone about 20 per cent., and chalk about 42 per cent. With an increase of temperature evaporation is rapid, and less water penetrates the surface. In a flat district evaporation is 50 per cent. less than in an undulating one. When springs flow from artificial gravel beds they are termed "land springs"; these are shallow, and their flow is not constant. "Main springs" are found in deeper strata, and yield a regular supply. Springs sometimes hold in solution some of the mineral constituents of the rocks through which they pass. In many of these the mineral matter is so excessive as to render the water unfit for ordinary drinking purposes, though they are of value medicinally. The temperature of such springs is often high.

Springs (*Geol.*) Springs may be divided into two classes in accordance with their origin: (1) Normal springs, sufficiently described above; and (2) THERMAL SPRINGS, which are due to the uprise of heated waters from a subterranean source. These latter bring up various substances in solution, and eventually deposit them at higher levels at the points where the temperatures of the adjoining rock are lower than those of the initial temperature of the spring.

Sprocket or **Sprocket Wheel** (*Eng., etc.*) A toothed wheel driven by a chain. In cycles the term is usually reserved for the wheel on the driving axle of the machine. *See* CYCLES.

Sproket Piece (*Carp. and Join.*) A tilting fillet fixed on the lower ends of roof rafters.

Spruce. *See* WOODS.

Sprue (*Foundry*). A channel or runner by which molten metal enters a mould. *See* GATE.

Spun Metal. *See* SPINNING METAL.

Spun Silk. *See* SILK.

Spun Yarn (*Eng.*) In engineering this term is applied chiefly to loosely spun hemp rope, which is used as packing for stuffing-boxes and joints in steam pipes.

Spur (*Print.*) *See* POINTS.

Spurious Disk (*Astron.*) Owing to light of all wave lengths not being brought to a focus at one point, the image (say of a star formed by a lens) is a disc, surrounded by a series of interference rings.

Spur Wheel (*Eng.*) A toothed wheel of the ordinary form, *i.e.* with the teeth on the outside of the rim.

Squabble (*Typog.*) To disturb the arrangement of lines of type so as to render it unfit for printing; *i.e.* to "pie" the matter.

Squall (*Meteorol.*) A local rush of air which restores normal conditions when the air has been disturbed by local causes. High wind and heavy downpours generally accompany it.

Square. A geometrical plane figure having four equal sides and four right angles.

—— (*Build., etc.*) One hundred square feet of boarding, slating, etc.

—— (*Eng., Carp., etc.*) A tool used for drawing, setting out, or testing right angles. It has a stock of wood or metal and a flat thin blade, usually of

steel, set at right angles to one edge of the stock. The squares used by workmen are usually in the form of a letter L; those used by draughtsmen are in the form of a letter T, and are therefore known as T-SQUARES.

Square and Flat (*Carp.*) Framing without moulding, and with a flat panel.

Square Centre (*Eng.*) A piece of steel placed in the back head or poppet of a lathe in place of the ordinary centre, in order to cut a conical hole in a piece of work placed in the lathe; its point is made in the form of a square-based pyramid, instead of being conical. When a hole of sufficient depth has been cut, the square centre is removed and an ordinary centre is substituted.

Squared Paper. Paper ruled with two sets of lines, often $\frac{1}{10}$th in., or 1 millimetre, apart; used for plotting curves from a series of numbers obtained by calculation or experiment.

Squared Rubble (*Build.*) Stone walling in which the stones are squared on the face.

Square Nosed Tool (*Eng.*) A metal turning tool with a straight cutting edge, at right angles to the axis of the tool; it is used for finishing work which has been roughed out by a round nosed or a pointed tool; the ridges left by the latter are removed by the straight cutting edge.

Square Packing (*Eng.*) Rope or gasket plaited into a square section for filling joints or stuffing-boxes.

Square Threaded Screw (*Eng.*) *See* SCREW.

Squaring Up (*Carp.*, *Eng.*, *etc.*) The production of sides or faces on a piece of work accurately at right angles to one another.

Squeezer (*Met.*) A machine by which a ball of puddled iron is pressed into a homogeneous mass, ready for the rolling mills.

Squills (*Botany*). The sliced and dried bulb of *Urginea scilla* (order, *Liliaceæ*) forms the drug of this name.

Squinch (*Architect.*) The arches or series of projecting courses carrying four of the sides of an octagonal spire across the angles of a square tower.

Squint (*Architect.*) *See* HAGIOSCOPE.

—— (*Build.*) A term loosely applied to an object cut at an obtuse or acute angle.

Squint Brick (*Build.*) A brick cut to an acute or obtuse angle.

Squirrel Cage Rotor (*Elect. Eng.*) A ROTOR or revolving portion of an alternating current motor, built up of parallel bars of copper, joined together at their ends by a conducting rim or disc.

Squirting (*Chem. Tech.*) *See* PLOTTING.

Sr (*Chem.*) The symbol for Strontium (*q.v.*)

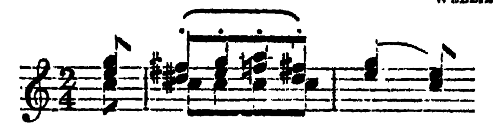
Stabbing (*Bind.*) A method of attaching the various sections or sheets of a volume or pamphlet together. The sections are placed in a pile, pierced near their back edge, and then secured by wire or thread passed through the holes. *See* SEWING *and* STITCHING.

Stable Equilibrium (*Phys.*, *Mech.*) *See* EQUILIBRIUM, STABLE.

Staccatissimo (*Music*). As separated as possible. *Cf.* STACCATO.

Staccato (*Music*) Detached, separated. Staccato is the opposite to *legato*. There are three degrees of staccato, shown respectively by dots with a slur, by dots, by dashes. The following brief examples show these, and an approximate idea of their performance is given beneath each:

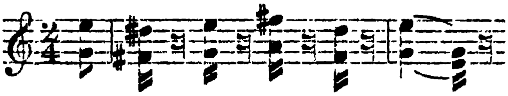
Ex. 1.—MEZZO STACCATO (as written). WEBER.



MEZZO STACCATO (as played), three-quarters note, one-quarter rest.

Ex. 2.—STACCATO (as written). WEBER.

STACCATO (as played), half note, half rest.



Ex. 3.—STACCATISSIMO (as written). MOZART.

STACCATISSIMO (as played), one-quarter note, three-quarters rest.

Stack. In engineering, a single tall chimney. Builders usually apply the term only to a number of chimneys or flues grouped together.

Stadia (*Surveying*). The staff used in conjunction with the tacheometer (*q.v.*) or similar instruments for the indirect measurement of distances.

Stadium (*Archæol.*) (1) A course on which foot races took place in Greece; the most celebrated were at Olympia and Athens. (2) The distance between the terminal pillars of the stadium, *viz.* 600 ft., equal to 625 Roman feet.

Staff (*Music*). *See* STAVE.

—— (*Watches*). The small spindle or arbor on which the balance (*q.v.*) is mounted. The arbor of the pallets of a lever watch is also called a staff. *See* ARBOR.

Staff Bead. *See* ANGLE BEAD.

Stafford Blues. *See* BRICKS.

Stage. (1) A flat surface forming a support; the term has many applications, *e.g.* a Landing Stage, the Stage of a theatre, etc. (2) The part of a microscope

(*q.v.*) or of an optical lantern which supports the slide or other object to be viewed. (3) A definite point in a series of operations, or one operation of a series.

Stage (*Geol.*) A name now applied to one of the minor groups of beds, which are themselves composed of several strata. Stages unite to form a Series, Series to form a System, and Systems to form a Group.

Stage Micrometer. *See* EYEPIECE MICROMETER.

Stage Pass (*Textiles*). *See* ENTERING.

Staggering (*Eng., Elect. Eng., etc.*) An arrangement of a number of separate objects, *e.g.* rivets, so that they are not exactly opposite to, or in line with, each other.

Stag's Head (*Her.*) The antlers of a stag in heraldry are called "attires"; the branches, "tynes."

Stain (*Dec.*) Colouring matter dissolved in oil, spirit, or water, and sufficiently transparent to show the grain of the wood through.

Stainers (*Dec.*) The popular term among painters for all pigments which are mixed with white lead, zinc white, etc., for painting purposes. *See* PAINT MIXING.

Staining (*Leather Manufac.*) Brushing over the surface of leather with a strong solution of a dye-stuff; commonly called BRUSH DYEING.

Staircase (*Build.*) Staircases are built of wood, stone, or iron, the former being employed in most private buildings. A wooden staircase consists of a succession of steps, each formed by two boards, one forming the TREAD or horizontal surface on which the foot rests, the other being placed vertically so as to fill in the space between two successive treads: this is termed a RISER. The edge of a tread usually projects beyond the riser, and is rounded off or moulded, forming a NOSING. If the nosing is carried round the end of a step, so as to cover the exposed end of the tread, it is termed a RETURNED NOSING. If a small scotia (*q.v.*) is fixed to the riser under the nosing, the latter is termed a BOTTLE-NOSE. A step with a rounded end is termed a BULL-NOSE STEP: this is often used for the lowest step of a flight. If this step has the end formed into a volute, corresponding to the form of the wreath on the end of the handrail, it is termed a CURTAIL STEP. The width of a tread is termed the GOING, the expression "going of a flight" being the horizontal distance over which the whole flight of steps extends. The ordinary steps, whose width is uniform, are termed FLIERS, those of triangular or tapering form, which occur where the stairs turn or "wind," being termed WINDERS. A winder which occurs right in the angle of a staircase is usually kite-shaped, and is termed a KITE WINDER. The ends of the treads and risers are supported by boards termed STRINGS, running the whole length of each flight. The string next to the wall is termed a WALL STRING, the other or outer one a WELL STRING, as it lies next to the WELL, or central space of the staircase, which is seen when looking down from an upper landing. If the upper edge of the string forms one continuous line, the term CLOSE STRING is applied to it; a CUT STRING is one which is cut out into right-angled notches following the profile of each step. The ends of each step in a cut string may be concealed by ornamental brackets fixed to the string, forming a BRACKETED STRING, or the ends of the risers may be mitred to the vertical edges of the notches in the string, thus forming what is termed a MITRED STRING, or CUT AND MITRED STRING. If the strings form a continuous line where the staircase bends round, they are said to be WREATHED, the same term being applied to the handrail. The latter is a moulded rail on which the hand rests; it is supported by vertical pillars, termed BALUSTERS, rising from each step; the large column at the end of a flight, to which the ends of a handrail are attached, is a NEWEL. Stairs are sometimes provided with extra support in the form of roughly made strings placed under the steps: these are termed ROUGH STRINGS or ROUGH CARRIAGES. The resting places between the flights are termed LANDINGS, a HALF SPACE LANDING being one which extends the whole width of the staircase, a QUARTER SPACE LANDING extending the width of one flight.

Stake. (1) A general term for a bar with a pointed end. (2) In the foundry a spike driven into the floor for holding a moulding box in position. (3) A form of anvil used by sheet metal workers; it generally has a small face or plain surface, and long projecting points or beak irons.

Staking (*Leather Manufac.*) Drawing leather, in a moist condition, vigorously over a bluntish blade fixed on an upright post. This stretches and softens the leather, and prevents the fibres from sticking together while drying.

Staking On (*Eng.*) Fixing a wheel on a shaft by means of several keys; the wheel is not accurately bored out to fit the shaft, but has an opening larger than the diameter of the shaft, and correct centring or adjustment is obtained by the keys alone.

Stalactites (*Geol.*) Pendent masses of some rock-forming mineral, rudely circular in cross section, which have been deposited on the inner side of the roof of a cavity by the slow evaporation of water holding the substance of that mineral in solution. The best known examples are those of carbonate of lime, such as may be seen depending from the soffit of a railway arch, and which are due to the solution of some of the carbonate of lime in the mortar, and its redeposition at a lower level under the joint influence of surface tension and gravitation. Nearly all limestone caverns contain stalactites of carbonate of lime. Stalactites may be formed by almost any mineral, *e.g.* hæmatite, chalcedony, malachite, etc.

Stalagmite (*Geol.*) Deposits found in the same manner as stalactites; but left upon the floor of the chamber instead of being pendent from the roof.

Stall Board (*Carp. and Join.*) The boarding inside a shop window on which the goods are displayed.

Stalls (*Architect.*) The fixed and partially enclosed seats in the chancel of a church, used by the clergy and others assisting in the services.

Stamnos (*Archæol.*) A two-handled earthenware Greek jar with very short neck, used for holding liquids; often decorated with red figures.

Stamp (*Met.*) (1) Specifically that portion of the machine of a stamp mill that delivers the blow by which ore is reduced to a suitable size for further treatment in the processes of separating the valuable constituents. (2) A STAMPING MACHINE (*q.v.*) (3) A STAMP MILL (*q.v.*) *See also* SLIME *and* STAMPS.

Stamping (*Textile Manufac.*) The operation of punching the cards for the harness loom according to a given design.

Stamping Machine, Stamping Press. (1) A machine used for forming metal articles, generally in the rough. (2) A machine, generally worked by power, for forming hollow metal utensils. The shaping is effected, not by a blow, but by a continuous pressure brought to bear on the dies.

Stamping Press (*Bind.*) *See* BLOCKING PRESS.

Stampings (*Eng., etc.*) Metal objects produced by means of dies actuated by a press or stamping machine. Some metals may be used in the cold; others require heating. Among the latter is wrought iron, stampings of which are frequently made, thereby saving much labour in the forge.

Stamp Mill (*Met.*) A machine or set of machines for crushing ore by means of vertical blows.

Stamps (*Met.*) Another name for NOBLINS. Also the rough bars of about 28 lb. each obtained by nicking or partially cutting through a bloom or noblin. The stamps are broken to judge the grain of the metal before preparing a "pile" in the production of malleable and sheet iron.

Stanchion. A vertical bar or post serving as a support; *e.g.* an iron column (which may be built into a wall) carrying the end of a girder.

Stancliffe *and* **Darley Dale Stone.** *See* BUILDING STONES.

Standard. A fixed measure, weight, value, or quality, established by law or sanctioned by usage and general consent, which serves as a definite unit of comparison. A flag or banner serving as the emblem of a government or society; an ensign.

—— (*Build.*) (1) A vertical support (*cf.* STANDARD, *Eng.*) (2) A vertical pole of a scaffold.

—— (*Eng.*) A term applied in a very wide sense to various supports, upright framing, etc., forming part of a machine, bridge, pier, or other structure.

Standard Candle. A sperm candle, consuming 120 grains (about 7·8 grams) of wax per hour, is taken as a standard of illumination, and the amount of light it affords, termed ONE CANDLE POWER, is used in determining the illuminating power of other sources of light. The two lights are compared by some form of Photometer (*q.v.*)

Standard Diets (*Hygiene*). *See* FOODS.

Standard Gold (*Met.*) *See* CARAT.

Standardisation. (1) The comparison of any measuring or recording instrument with another of greater accuracy, or with one whose errors are exactly known. (2) In engineering, etc., the production of component parts of machines or structures in accordance with certain sets of measurements previously agreed upon.

Standard Rule (*Eng., etc.*) A rule divided exactly into inches, etc., as distinguished from a CONTRACTION RULE (*q.v.*)

Standard Solutions. For the purposes of volumetric analysis, and for a great number of different purposes in chemistry and other scientific and technical work, it is necessary to have solutions of various substances of accurately known strength; this strength is generally chosen with reference to some convenient standard depending on the precise use for which the solution is required. For example, solutions of an acid and of an alkali may be so made up that equal volumes exactly neutralise each other; in this case the quantities (by weight) of the acid and alkali contained in equal volumes of the solution are proportional to their respective reacting weights. A solution containing 35·5 grams of HCl will neutralise another containing 40 grams of NaOH. If the two amounts are each contained in 1 litre of solution, the latter is termed a NORMAL SOLUTION. A DECI-NORMAL SOLUTION is one-tenth of this strength, and so on for other strengths. Standard solutions may, of course, be made of any other strength (subject to the solubility of the given substance); *e.g.* a solution of silver nitrate may be made so that 1 c.c. will exactly correspond to 1 milligram of common salt or 1 milligram of chlorine.

Standard Time (*Astron.*) The time at every meridian fifteen degrees apart, commencing with the Greenwich meridian.

Standard Wire Gauge. *See* WIRE GAUGES.

Stand Pipe. (1) A large vertical pipe at a water source, into which water is forced in order to obtain sufficient pressure to carry it to a distance. (2) A small vertical pipe having direct connection with a water main. (3) A pipe sufficiently high to force water into a boiler against steam pressure.

Stanford's Patent Drain Joint (*San.*) is one in which the spigot and socket ends of each pipe are provided with a mould of smooth plastic material, causing them to fit accurately into each other. By greasing the prepared ends with rosin and melted tallow a perfect joint is formed.

Stanhope Press. *See* TYPOGRAPHY.

Stannates (*Chem.*) *See* TIN COMPOUNDS.

Stannic, Stannous, Stannum (*Chem.*) Stannum is the Latin name for tin; from it the chemical symbol for tin, Sn, is derived. Stannic is the prefix applied to tetravalent tin compounds. Stannous is the prefix applied to divalent tin compounds. *See* TIN.

Stannine (*Min.*) A sulphide of tin, copper, and iron, $Cu_2S(Fe,Zn)S \cdot SnS_2$; tin = 27, copper = 30, iron = 13, sulphur = 30 per cent. Also called Bell Metal Ore and Tin Pyrites. Cubic; colour greyish or bronze (hence Bell Metal Ore). If abundant it is used as an ore of tin. From several localities in Cornwall, from Zinnwald in Bohemia, etc.

Staple (*Build., etc.*) A piece of metal rod or wire pointed at the ends and bent into the shape of the letter U.

—— (*Textile Manufac.*) In the woollen and worsted trades a lock of wool. The quality and properties of wool are determined by the strength, length, and elasticity of the staple. For cotton, *see under* GRADING.

Starch (*Chem.*) $(C_{12}H_{20}O_{10})n$. A white powder, with or without lustre, according to its source. It is composed of small granules, having an organised structure, but varying greatly in this respect and also in size. Starch from various sources can be identified by a miscroscopic examination of the structure and size of the granule. For example, potato starch consists of circular or oval granules marked with rings, and a circular or stellar hilum, and a size from ·06 to ·1 mm. Starch ordinarily contains about 20 per cent. of water; if exposed to moist air, this amount may be much exceeded. It loses its water in a current of dry air at 100° to 105°. Does not melt when heated. Ordinary starch at 160° is converted into dextrine (British gum), which is soluble in water. Perfectly dried starch is not decompoble in

160°, but is decomposed at higher temperatures. Starch is insoluble in cold water, but when made into a paste with cold water and then heated the granules are gelatinised, the temperature at which this occurs varying with the kind of starch. If the cold paste (5 grams starch to 100 cc. water) be acted on by diastase for a few minutes only and then filtered, the solution contains starch, and an insoluble residue remains on the filter paper. The soluble part is called starch granulose, and the insoluble part starch cellulose, and it is the former which gives the dark blue colour with iodine. When the product of the action of diastase just referred to is quickly boiled to destroy the enzyme, filtered, and then concentrated, a white precipitate separates on cooling. The precipitate, allowed to stand a few days, and then well washed with water, gives SOLUBLE STARCH. This variety of starch is completely, but rather sparingly, soluble in water; it is a colloid; its solution is dextrorotatory, gives a blue colour with iodine, and does not reduce Fehling's solution. Boiling dilute acids convert starch first into soluble starch, then dextrine and maltose, and finally into dextrose. The action of nitric acid is very various. Fuming nitric acid (sp. gr. 1·5) gives an explosive nitrate or mixture of nitrates; a more dilute acid gives saccharic acid (*q.v.*); prolonged boiling with such an acid (sp. gr. 1·2) gives finally oxalic acid. With the diluted acid large quantities of nitric oxide and nitrogen peroxide are evolved. Iodine gives with starch a deep blue colour, which disappears on heating and reappears on cooling. What the blue compound is is quite unknown. Its production serves as a very delicate test for starch or iodine (it will detect ·000003 gram iodine). The action of diastase is very important. When starch paste is acted on by diastase at 60°, the starch paste becomes quite thin, and loses its power of giving a blue colour with iodine, acquiring instead the power of giving a brownish-red colour, and lastly it loses this power. The final products are maltose and dextrine. Potato starch gives more dextrine and less maltose than any other starch.

PREPARATION AND COMMERCIAL USES: Starch is used for a great variety of purposes: as a food in the form of the various cornflours, for infants' foods, and as arrowroot, etc.; for sizing paper and cloth, for the preparation of British gum and glucose, for laundry purposes. It is prepared in England chiefly from rice, in America from maize, in Germany and France from potatoes. Various processes are employed, but all are in the main mechanical. One process from rice is to digest the rice with very dilute caustic soda (about 1 in 350) solution for twenty-four hours, the liquor is drawn off, and the residue washed with water. The caustic soda removes the gluten which binds the starch granules in the rice. The residue is ground to powder, which is then sieved, and the fine product again treated with alkali as before, only it is frequently stirred during the twenty-four hours, and then left to stand seventy hours. The liquor is run away, the residue well stirred with twice as much water as soda solution, left an hour, and the turbid liquid, which now only contains the starch in suspension, run through fine silk sieves. The sieved liquor deposits the starch on standing, the water is drawn off, the starch drained, and dried in a current of air (six to eight weeks).

Starch (*Foods*). This exists in various farinacea in the form of microscopic granules, differing in form and size according to their origin. When acted upon by the saliva and pancreatic juice it becomes grape sugar; this, when taken up by the blood, is carried to the liver, where it becomes glycogen (*q.v.*), and from thence is supplied to the system. *See also* STARCH (*Chem.*)

Star Charts (*Astron.*) Maps on which the relative positions of stars are plotted. The positions are determined from observations with the transit circle, or more recently from photographs.

Star Connections (*Elect. Eng.*) An arrangement of the coils of a three phase motor, such that they have a common junction.

Star Magnitudes (*Astron.*) Stars were classified, long before the telescope was invented, according to their relative brilliancies. Those which appear largest and brightest are termed Stars of the First Magnitude; the next, stars of the Second Magnitude, and so on to the smallest stars visible to the naked eye, which are said to be of the Sixth Magnitude. The telescope has, of course, greatly increased the number, and the stars visible with a powerful instrument are classified down to the seventeenth or eighteenth magnitude, or even beyond. The number of stars in each magnitude is approximately given by Sir Robert Ball as follows:

1st magnitude	20
2nd ,,	65
3rd ,,	190
4th ,,	425
5th ,,	1,100
6th ,,	3,200
7th ,,	13,000
8th ,,	40,000
9th ,,	142,000

Star Moulding (*Architect.*) An enriched Norman moulding consisting of a series of sunk stars.

Starting Engine (*Eng.*) A subsidiary engine used on steamships to set the main engine in motion.

Starting Gear (*Eng.*) A term which comprises the whole of the mechanism called into action in order to start the motion of an engine or other machine.

Starting Valve (*Eng.*) The valve in a steam engine which admits steam from the boiler into the steam chest.

Star Wheel (*Eng.*) A ratchet wheel with large pointed teeth. It is used in various forms of ratchet feed, as, for example, on self acting lathes, when employed in surfacing (*q.v.*)

Stassfurt Deposits (*Chem.*) Large deposits of common salt and potassium and magnesium salts, which occur at Stassfurt, near Magdeburg. They have been formed by the evaporation of sea water. The potassium and magnesium compounds occur as double salts in fairly distinct layers in the order from above downwards:—

(1) Carnallite ($KCl.MgCl_2 6H_2O$), with kainite ($KCl.MgSO_4 3H_2O$), kieserite ($MgSO_4 H_2O$), schönite ($K_2SO_4 MgSO_4 6H_2O$), and sylvine (KCl), and a good deal of rock salt.

(2) Kieserite ($MgSO_4 H_2O$), with much rock salt and a fair amount of carnallite.

(3) Polyhalite ($2CaSO_4.MgSO_4.K_2SO_4 2H_2O$), along with a very large amount of rock salt.

(4) Rock salt ($NaCl$).

Besides these, certain amounts of borates and bromides occur. These deposits are the principal source of potassium compounds for the whole world. To give some idea of the scale on which they are worked,

it may be mentioned that in 1900 about 16,400 persons were engaged in working these salts at Stassfurt and the district around. In 1898 the production of potassium salts amounted to 2,200,000 metric tons (1 metric ton = 1,000 kilograms = ·9842 tons), of bromine 500 metric tons, and, in addition to these, large quantities of magnesium salts and boric acid. (*See* POTASSIUM *and* MAGNESIUM COMPOUNDS.) Extensive researches on the chemistry of the formation of these salts have been made with the aid of the Phase Rule, but these cannot be given here. *See* Findlay's "Phase Rule."

Stassfurtite (*Geol.*) A salt found in the Carnalite region. It is a massive variety of Boracite (*q.v.*)

State (*Engrav.*) When an engraved plate is nearing completion, proofs are taken at different stages to test its condition. These proofs are termed proofs of the first state, second state, and so on. When the engraving is completed the plate is referred to as being in the FINAL STATE. *See* PROOF.

Static Electricity *or* **Electrostatics.** The phenomena associated with charges of electricity at rest; the branch of the science of electricity dealing with these phenomena.

Static Fatigue (*Eng.*) Elastic fatigue (*q.v.*), produced by a continuous stress.

Static Friction. *See* FRICTION, STATIC.

Statics. The branch of theoretical mechanics dealing with forces at rest or in equilibrium.

Station (*Elect. Eng.*) A place at which electrical machinery or apparatus is maintained and operated; *e.g.* a CENTRAL STATION is the main building in which the engines and dynamos are placed for the supply of current to a lighting or power circuit. A TRANSFORMER STATION or SUBSTATION contains transformers (*q.v.*) for changing the voltage for distribution.

—— (*Eng., etc.*) (1) A building, etc., in which some form of central plant is located, *e.g.* a pumping station. (2) A stopping place on a railway for taking up or setting down passengers or goods, for shunting, making up trains, etc.

—— (*Mining*). A recess in a mine to provide a space in which cars can pass one another.

—— (*Survey, etc.*) A point from which measurements by distances or angles are made.

Stationary Engine (*Eng.*) An engine mounted on a fixed bedplate.

Stationary Points (*Astron.*) Points in a planet's apparent path where, as seen from the earth, the planet appears stationary or is moving in a direction either towards or away from the earth.

Stationary Waves. Periodic displacements occurring in a medium between successive points, termed the NODES, which remain permanently at rest. They are produced when two trains of equal and similar waves travel through the medium with equal velocities, but in opposite directions. The ordinary vibrations of a stretched string furnish an example.

Stator (*Elect. Eng.*) The stationary part of a polyphase motor carrying the windings through which the primary current flows. *Cf.* ROTOR, *and see* MOTORS, ELECTRIC.

Statuary Marble. *See* MARBLE, STATUARY.

Statue. A plastic work in marble, bronze, wood, or other material, representing a human or animal figure. *Cf.* STATUETTE.

Statue, Monumental. A recumbent figure on a slab covering a mediæval tomb.

Statuette. A statue (*q.v.*) the dimensions of which are generally less than half life size.

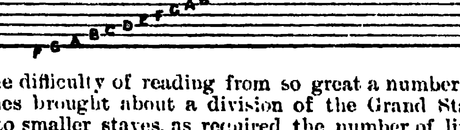
Staunch (*Eng.*) A joint in a boiler, etc., is said to be staunch when it is watertight.

Staurolite (*Min.*) An iron aluminium silicate, $H_2O.2FeO, 5Al_2O_3.4SiO_2$; silica = 29·3, alumina = 53·9, ferric oxide = 17·2 per cent. Orthorhombic, often in cruciform twins, whence the name Staurolite. Colour brown to black. It is found in some metamorphic rocks, as the slates of Devon and Cornwall. Also in Co. Dublin and Co. Wicklow; in Aberdeenshire; Switzerland, the United States, etc.

Stave (*Eng.*) A rod projecting from a large piece of iron. The iron is manipulated by means of the stave during forging operations.

—— *or* **Staff** (*Music*). A set of horizontal and parallel lines with equal spaces between. Upon the lines and between the spaces the notes and rests are placed. Each line and each space is called a degree, the degrees being reckoned from the bottom upwards. The present staves are derived from a stave of eleven lines called the Grand or Great Stave, the lines and spaces of which were as follows:

GRAND STAVE.

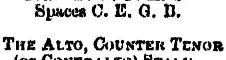


The difficulty of reading from so great a number of lines brought about a division of the Grand Stave into smaller staves, as required, the number of lines of which have varied from time to time. Old manuscript books often have staves of six lines, the lines of which correspond to the present Treble Stave (*see* below), with middle C line (the sixth line of the Grand Stave) added below. Plain song is still written on a stave of four lines. (*See* MODES.) The stave of five lines is now used for all kinds of music except Plain song. The splitting up of the Grand Stave into smaller staves required signs called clefs (*q.v.*) to indicate which set of lines had been taken from the eleven. These clefs appear to move in the different staves; but in reality this is not the case. The clef is stationary, but the lines chosen from the Grand Stave vary. The following show the different staves, and which lines of the Grand Stave were selected for each:

1. THE BASS STAVE.
(Lines 1, 2, 3, 4, 5.)

Lines G. B. D. F. A.
Spaces A. C. E. G.

2. THE BARITONE STAVE.
(Lines 2, 3, 4, 5, 6.)



Lines B. D. F. A. C.
Spaces C. E. G. B.

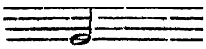
3. THE TENOR STAVE.
(Lines 3, 4, 5, 6, 7.)

Lines D. F. A. C. E.
Spaces E. G. B. D.

THE ALTO, COUNTER TENOR (or CONTRALTO) STAVE.
(Lines 4, 5, 6, 7, 8.)

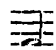
Lines F. A. C. E. G.
Spaces G. B. D. F.

5. The Mezzo-Soprano Stave.
(Lines 5. 6. 7. 8. 9.)



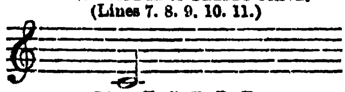
Lines A. C. E. G. B.
Spaces B. D. F. A.

6. The Soprano Stave.
(Lines 6. 7. 8. 9. 10.)



Lines C. E. G. B. D.)
Spaces D. F. A. C.

7. The Fiddle or Treble Stave.
(Lines 7. 8. 9. 10. 11.)



Lines E. G. B. D. F.
Spaces F. A. C. E.

The note shown on each stave is Middle C, *i.e.* the 6th line of the Great Stave. Of these seven staves Nos. 2 and 5 are obsolete, and Nos. 3, 4, and 6 unfortunately are rapidly disappearing. This, in the case of the Tenor and Alto staves, is to be greatly regretted, for music for these voices can readily be written at the proper pitch on their respective staves, whereas with the modern notation, *i.e.* employing the Treble stave for the Tenor and even for Bass songs, the notes, of course, are an octave higher than they are sung. (*See* Score.) When the compass of a piece exceeds that which can be written on the stave, short lines called Leger lines (*q.v.*) are added above or below the stave. With the exception of those above the Treble or below the Bass, these leger lines are simply other lines borrowed from the Great Stave. Hence, the first leger line above the Bass stave C is the same as the first leger line below the treble stave C, and is known as Middle C (*q.v.*) It is unusual to use many leger lines, but when the note or notes are exceptionally high or low, the notes are written respectively an octave lower and the sign 8ve . . . added as an indication that they are to be performed an octave higher than written; or the notes are written an octave higher and 8va bassa . . . added as an indication that they are to be performed an octave lower than written. *See also* Loco.

Stay (*Eng.*) A bar used to strengthen or stiffen a structure. *See also* Strut *and* Tie Rod.

Stayed Link Chain (*Eng.*) A heavy chain in which each link is strengthened by a bar welded to the link, giving the latter the form of the Greek letter θ.

Staying (*Eng., Build., etc.*) Strengthening any object by the addition of stays; boilers, iron roofs, and all large engineering structures supply abundant examples.

Stay Tap (*Eng.*) A long Tap (*q.v.*) used in screwing holes in the shells of boilers for the reception of the ends of stays.

Stay Tubes (*Eng.*) A boiler tube (*see* Boilers) which serves to stiffen the shell of the boiler in addition to its function as a tube.

St. Bees Sandstone (*Geol.*) A local development of the Bunter Series of the Trias or Upper New Red, occurring chiefly in Arran, Ayrshire, Dumfriesshire, Cumberland, and Westmorland. It is well seen at St. Bees, on the Cumberland Coast, near Whitehaven, where, however, only its lowest third remains. The full thickness is to be seen only in Arran and near Ousby in Cumberland, where it amounts to 2000 ft. In the north-west of England it is underlaid by the Bunter Marls, in which the gypsum quarries are worked; and it is overlain there by the Keuper Marls, which are about 900 feet in thickness.

Steady *or* **Back Rest** (*Eng.*) A support used to prevent bending of a long piece of work which is being turned in the lathe.

Steadying Bands (*Cotton Spinning*). Check bands on a mule for keeping the carriage "square" when running out.

Steady Pin (*Eng., etc.*) A dowell (*q.v.*) or projecting pin which prevents the relative motion of two parts of an object.

Steam.—The vapour of water, usually applied to the hot vapour given off at the boiling point (212° F. or higher). True steam is invisible, the white cloud often termed steam being really a collection of fine drops of water formed by condensation. If water be allowed to evaporate into any closed space, the process will go on up to a certain point, beyond which no more vapour will be formed unless the temperature be raised, or the pressure lowered by allowing some of the steam to escape. The steam is then said to be Saturated. Saturated steam can have but one temperature corresponding to any given pressure; but if the steam be removed from contact with the water, its temperature may be raised just as that of any other gas may be; the steam is then said to be Superheated. The relation of the pressure and temperature of saturated steam is thus given by Ewing :—

Temperature (Fahrenheit).	Pressure (lb. per sq. in.).
212°	14·7
230°	20·8
275°	45·5
302°	69·2
347°	129·8
401°	250·3

By plotting a curve with these numbers for abscissæ and ordinates, the pressure of saturated steam for any intermediate temperature can be readily found. The Total Heat of steam is the amount of heat required to raise 1 lb. of water from the freezing point (32° F.) to its boiling point, and then to evaporate it under constant pressure. If t be the temperature of evaporation (or boiling point) then H, the total heat, is given by the equation

$$H = 1091{\cdot}7 + {\cdot}305\,(t - 32°).$$

Saturated steam may be mixed with a certain quantity of water, usually in the form of suspended drops : it is then termed Wet Steam.

Steam Boiler (*Eng.*) *See* Boiler.

Steam Brake (*Eng.*) A form of brake used on locomotives, in which the mechanism for applying the brake block is worked by a cylinder and piston supplied with steam from the boiler.

Steam Chest (*Eng.*) (1) A Valve Box or Chest (*q.v.*) (2) A receptacle on the top of a boiler in which steam can collect, and from which the steam pipe leading to the cylinder runs.

Steam Coal (*Eng.*) Coal suitable for use in boilers. The best form is Anthracite. *See* Coal.

Steam Cock (*Eng.*) In general any tap used for controlling a supply of steam, especially a tap or cock opening into a boiler above the water line. It serves to show, when opened, whether the boiler contains too much water.

Steam Coil (*Build., etc.*) A coil of pipe through which a current of steam flows; used in heating buildings, etc., by steam.

Steam Corner (*Eng.*) The corner of an INDICATOR DIAGRAM (*q.v.*) which shows the end of the process of exhaustion of the steam and the commencement of the admission of fresh steam.

Steam Distillation (*Chem.*) *See* DISTILLATION.

Steam Dome (*Eng.*) A STEAM CHEST (*q.v.*) on top of a boiler.

Steam Economiser (*Eng.*) *See* BOILERS *and* ECONOMISERS.

Steam Engine. The steam engine is a mechanism for obtaining mechanical energy from the heat energy stored up in steam. This heat energy is derived from the combustion of fuel in the boiler fire, and its presence in the steam accounts for the physical change which the water in the boiler has undergone during the process known as evaporation. The steam is produced from water at a pressure considerably above that of the atmosphere, and is delivered to the engine with as little loss of pressure and heat as possible. The higher the pressure of the steam, the greater will be the amount of heat available, in a given weight of steam, for conversion into mechanical energy. Only a fraction of the total heat energy given to the steam in the boiler is converted into mechanical work in the engine. By far the greater portion still remains in the steam after it has passed through the engine. The proportion of heat utilised depends on the thermal efficiency of the engine, amounting from 12 to 15 per cent. in good condensing engines; in the very best engines of large size it may be as high as 20 per cent. The conversion of energy is effected by admitting a quantity of steam into the engine cylinder and allowing it to expand, the expansion causing the piston to be pushed forward. The displacement, or stroke, of the piston is limited to a fixed length by the crank; and at the end of the stroke the space occupied by the steam will be from twice to four times the original volume, or even more. During expansion both the pressure and temperature of the steam are lowered, and the heat energy is reduced by an amount equivalent to the work done by the steam in pushing the piston and the mechanism attached to it through the distance represented by the stroke. This process is repeated at each successive stroke of the engine, so that the supply of steam passing through the engine approximates to a steady

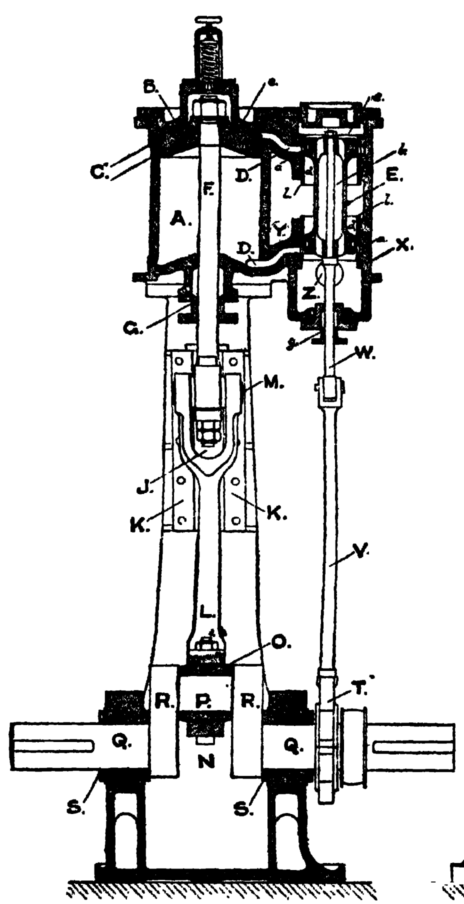


FIG. 1. VERTICAL SIMPLE ENGINE. FRONT SECTIONAL ELEVATION.

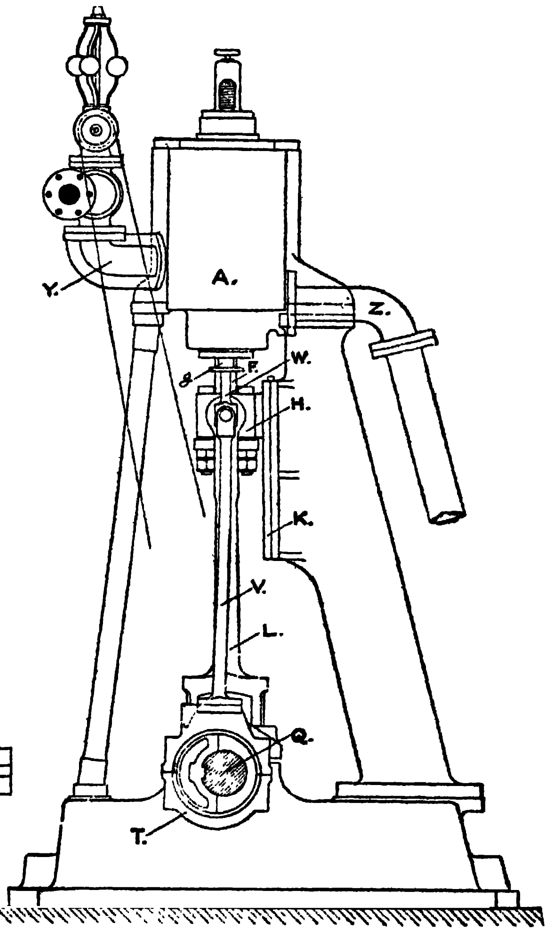


FIG. 2. VERTICAL SIMPLE ENGINE. SIDE ELEVATION.

flow. The engine consists of a hollow **CYLINDER A** (*see* figs. 1 and 2), closed at both ends; inside it is the **PISTON B**, a sliding partition which fits the bore of the cylinder sufficiently closely to prevent the steam leaking past it, but having sufficient freedom to allow it to move from end to end of the cylinder with as little friction as possible. This is effected by the **PISTON RINGS C**, which are made slightly larger in diameter than the cylinder bore, but have a sufficient portion of their circumference cut away to allow of their being sprung into the cylinder. Passages, or **PORTS, DD**, are provided at the ends of the cylinder, by which the steam can enter or leave. These ports are opened and closed by the **SLIDE VALVE E**, the movement of which is actuated by the piston in the manner described below. The **PISTON ROD F**, which is rigidly attached to the piston, is of circular section, and has its centre line concentric with the piston and cylinder. It passes out through one end of the cylinder, and is somewhat longer than the latter, so that a portion of its length is always outside the cylinder. By this means the connection is made between the piston and the external moving parts of the engine. The hole in the cylinder end, through which the rod projects, is made steam-tight by the **GLAND G**, which fits round the rod closely, at the same time producing as little friction as possible. The external end of the rod is rigidly attached to the **CROSSHEAD H**, a block sliding on the **FACING J**, to which it is held by **GUIDES K K**, the arrangement serving to keep the axis of the piston and piston rod in line with that of the cylinder. If the engine is intended to produce rotary motion, the crosshead has a **CONNECTING ROD L** attached to it by means of the **CROSSHEAD PIN M**. This pin passes through the end of the connecting rod and the centre of the crosshead, forming a joint, so that the rod is free to follow the movements of the **CRANK N**, to which the other end of it is attached. A bearing O is provided at the crank end of the connecting rod, in which the **CRANK PIN P** rotates as the **CRANK SHAFT Q** revolves. The crank pin, **CRANK CHEEKS RR**, and shaft all form one rigid piece, which is carried in the **CRANK SHAFT BEARINGS SS**, placed as near to the crank as possible. On the shaft, close to one of the bearings, is fixed the **ECCENTRIC T**, which actuates the **SLIDE VALVE E** by means of the **ECCENTRIC ROD V** and **VALVE ROD W**. The valve rod passes through a **GLAND** *g* into the **VALVE CHEST X**, and is rigidly attached to the valve. The latter (shown in the form known as the **PISTON SLIDE VALVE**) fits the **LINERS** *l l* much in the same way as the piston fits the cylinder. It, however, fits only along the two end portions of its surface, the intermediate portion being recessed to a smaller diameter, in order that the annular space thus formed may serve as a passage for steam in certain positions of the valve. Y is the **STEAM INLET PIPE**, and from it, when the valve is in the right position, steam can enter the top portion of the cylinder *o* by means of the annular space *d*, which is formed between the liner *l* and the middle portion of the valve body, thence through the hole *a* in the liner and along the port D. The admission of steam into the bottom portion of the cylinder, on the upstroke, is similar. Z is the **EXHAUST PIPE**, by which the steam on leaving the cylinder passes away to the condenser or escapes into the atmosphere. From the upper port D, its passage is by means of the hole *a* to the top part of the valve chest *c*, thence through the hollow portion of the valve body *b*, into the lower part of the chest and out at Z. From the bottom port the steam passes through the hole in the liner direct into the lower part of the valve chest and out at Z. The action of the engine is as follows: When the piston is at the top of its stroke, the position of the valve is such that **ADMISSION** of steam takes place from the body of the valve chest to the space *o*, and the pressure of the steam tends to force the piston downwards. If the engine shown in figs. 1 and 2 were at a standstill, with the piston at the top of its stroke, no movement would take place, as the crank is on the **DEAD CENTRE** (*q.v.*) The engine must be assumed to be already in motion. During the downward movement of the piston, steam continues to flow into the top of the cylinder till a certain fraction of the stroke is reached, when the valve closes the hole *a*, and the supply of steam is **CUT OFF**. The imprisoned volume of steam then begins to expand, pushing the piston farther downwards, though with continually diminishing pressure, till its stroke is nearly completed, when the valve opens the top port D to the exhaust. Just before the piston comes to the end of its stroke, the lower port D is opened to steam by the valve, and the same process is repeated in the bottom portion of the cylinder during the upstroke. While the greater portion of the upstroke is taking place the top port remains open, and the steam continues to **EXHAUST** until the piston is near the top of its stroke, when the valve closes the port again. The imprisoned steam is then compressed during the remainder of the stroke, its pressure at the same time continually rising. This **COMPRESSION** produces a cushioning effect, which assists the reversal of the motion of the piston, and also tends to improve the thermal efficiency of the engine by reducing clearance losses and initial condensation. As the piston gets to the top of its stroke the valve again opens and admits steam above it, and the whole process of admission, cut off, exhaust, and compression is repeated.

There are many different types of engines, the particular design depending generally on the class of work for which the engine is intended; but distinct types are often employed for the same kind of work. For the purpose of dealing with the chief points of difference the following several classifications are employed:

I. Condensing and Non-Condensing.
II. Simple, Compound, and Multiple Expansion.
III. High Speed and Slow Speed.
IV. Vertical, Horizontal, Beam, Rotary, etc.
V. Marine, Locomotive, Electric Generating, Pumping, Mill Driving, Winding, etc.

I. *Condensing and Non-Condensing Engines.*—A **CONDENSING ENGINE** is one in which the steam, on leaving the cylinder, exhausts into a condenser, where the pressure is maintained as much below that of the atmosphere as possible. By this means the back pressure, *i.e.* the retarding pressure on the other side of the piston, is reduced, and it is possible to have a higher degree of expansion in the cylinder, and so to convert a larger fraction of the heat energy contained in the steam into mechanical work, than is the case with the **NON-CONDENSING ENGINE**. The latter simply exhausts its steam into the atmosphere, and can, therefore, only have the expansion carried to a pressure slightly above that of the atmosphere.

II. *Simple Engines, Compound and Multiple Expansion Engines.*—In the engine shown in figs. 1 and 2, and described above, the whole expansion of the steam takes place in one cylinder. The amount of expansion or "number of expansions" is the

ratio of the volume occupied by the steam at the beginning of the exhaust, to that occupied at the moment of cut off; and it would at first sight appear that this is only limited by the relative amounts of the pressure of the steam supplied to the engine, and the pressure of the atmosphere or condenser into which it exhausts, and that the best results would be obtained when the ratio of expansion was as near to this limit as possible. It is found, however, that beyond a certain point the gain by increased expansion is more than counterbalanced by other losses, both mechanical and thermodynamic, which are introduced, and also by the increased size and cost of the engine. By allowing the steam, after exhausting from one cylinder, to expand further in a second cylinder, both pistons being connected to the same shaft, the ratio of expansion giving the best economy is considerably increased, and with it the thermal efficiency of the engine. An engine with two cylinders arranged in this way is called a COMPOUND ENGINE (*see* figs. 5, 7, etc.), while an engine in which the expansion is completed in one cylinder is called a SIMPLE ENGINE (*see* figs. 3, 4, 10, etc.) The expansion may be still further increased with advantage in large condensing engines by employing three cylinders, in each of which successive

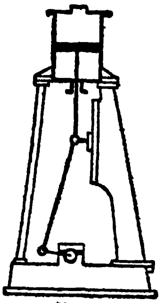


FIG. 3.
VERTICAL ENGINE.

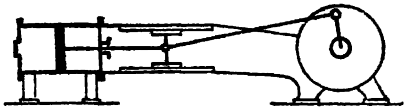


FIG. 4—HORIZONTAL ENGINE.

stages of the expansion take place. An engine of this sort is known as a TRIPLE EXPANSION ENGINE (*see* fig. 6). QUADRUPLE EXPANSION

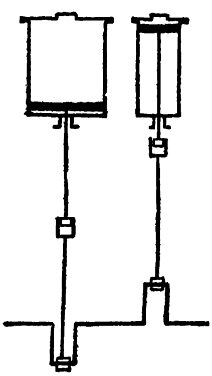


FIG. 5.
COMPOUND ENGINE

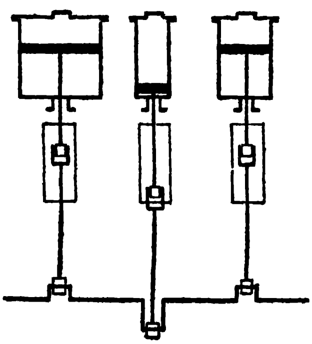


FIG. 6.
TRIPLE EXPANSION ENGINE.

ENGINES, in which there are four cylinders, each forming a separate stage of the expansion, are also built, chiefly for the largest class of marine work.

III. *High and Slow Speed Engines.*—This classification is a rather indefinite one; the size of an engine must be taken into consideration as well as the actual speed in determining which of these classes it belongs to. Up to 70 or 80 double strokes per minute would be considered a slow speed in a small engine, while in one of very large size it would be considered high. The engines of torpedo-boat destroyers, and some of the smaller engines for driving electric generators, run at as many as 400 to 600 revolutions per minute, and are considered very high speed. Large pumping engines only make from 20 to 40 double strokes per minute, and are probably the slowest type of engine built.

IV. *Vertical, Horizontal, Beam, Rotary, and Other Engines.*—Engines are classed as VERTICAL or HORIZONTAL according as the axes of their cylinders are vertical or horizontal (*see* figs. 3 and 4). Some

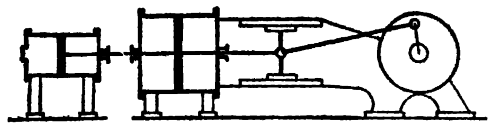


FIG. 7.—TANDEM ENGINE.

engines have one cylinder vertical and the other horizontal, as shown in fig. 9. BEAM ENGINES may

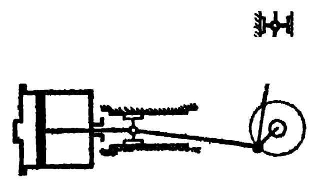


FIG. 8.
COMBINED VERTICAL AND HORIZONTAL ENGINE.

have either vertical or horizontal cylinders. The pistons and driven mechanism are connected to the

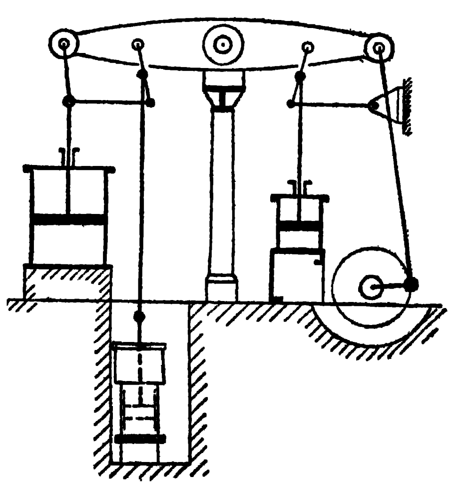


FIG. 9.
COMPOUND BEAM ENGINE WITH AIR PUMP.

ends of a large beam, supported by a shaft passing through its midpoint. When the engine is a vertical one the beam is straight, as shown in fig. 9; and when horizontal the beam is made in the form of a bell crank, as shown in fig. 10. The straight

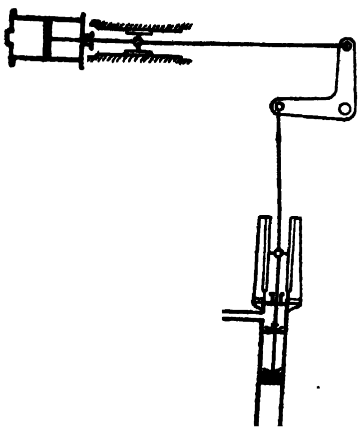


FIG. 10.—PUMPING ENGINE WITH QUADRANT BEAM.

beam is the more usual type, but both are now nearly obsolete. The BROTHERHOOD ENGINE consists of three cylinders placed with their axes at 120° to one another, as shown in fig. 11, all three connecting rods being coupled to a common crank pin. The pistons are single acting, *i.e.* the steam is admitted to one side only, and the body of each piston is lengthened out, so that no crosshead or piston rod is required. The cylinders of both horizontal and vertical engines are often placed one behind the other with their axes in line, so that a common piston rod serves for both. An arrangement of this sort is known as a TANDEM ENGINE (*see* fig. 7), as distinguished from the SIDE-BY-SIDE type, shown in fig. 5. A ROTARY ENGINE is one in which the motion of the piston is rotary, instead of taking place in a straight line; but the term is sometimes applied also to all engines producing rotary motion. There are a good many types of this class, but they are not used to any great extent for practical purposes. The general principle of the rotary engine is shown in fig. 12. A modification of this class is the SPHERICAL ENGINE.

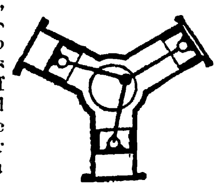


FIG 11.
BROTHERHOOD ENGINE.

V. *Marine, Locomotive, Electric Generating, Pumping, Mill Driving, Winding, and Other Engines.* — In many cases distinct types of engines have been developed to perform particular duties or to work in special positions. MARINE ENGINES are probably the most numerous class, and are built in sizes far exceeding those of any other type. They are condensing engines, and are either compound, triple, or quadruple expansion. For driving screw vessels the vertical type is used, with the cylinders above the shaft. For small paddle steamers the cylinders are usually below the shaft, and, as the height of the latter above the bottom of the boat is limited, the cylinders are fixed on trunnions, which allow them to oscillate and follow the movement of the crank, thereby dispensing with crossheads and connecting rods. In large paddle boats the cylinders are fixed at an angle to the horizontal, crossheads and connecting rods being used. This is known as the DIAGONAL type. LOCOMOTIVE ENGINES are, from the nature of their work, always horizontal and non-condensing. They consist of two or more cylinders, the cranks being placed at right angles for two cylinders in order that the engine may be able to start in any position of the cranks. A considerable number of locomotives are built with compound engines. ENGINES FOR DRIVING ELECTRIC GENERATORS are of many different types. In large sizes they are compound or triple expansion, and, where possible, are condensing engines. Both horizontal and vertical engines are used, but the latter type is becoming the more common of the two. Its advantage lies in the saving of floor space, owing to the smaller area occupied and the fact that, on account of the higher speed at which it can be run, the engine shaft can be coupled direct to that of the generator, instead of requiring a rope or belt drive, as is the case with horizontal engines. PUMPING ENGINES of recent design are arranged to drive direct, *i.e.* the piston rod of the engine is in line with and rigidly attached to that of the pump (*see* Fig. 13). Very often a flywheel is attached, by means of a connecting rod or rods, to a crosshead fixed at some convenient point on the piston rod. Both vertical and horizontal engines are employed for pumping. In the older types, beam engines, with either straight or quadrant beams, were used. For MILL DRIVING, compound or triple expansion engines are employed, and are almost always condensing. The horizontal type is most largely used for this class of work, although vertical engines and, in a good many instances, beam engines, are also employed. WINDING ENGINES are used for lifting coal or other minerals to the surface, and are always horizontal. In a few recent instances they are arranged to work condensing, but the usual type is non-condensing. Tandem compound engines are sometimes employed for the heaviest class of winding. Except in very old engines, all sizes are built with two cylinders or sets of cylinders arranged one on each side of the winding drum, the cranks being fixed at right angles.—W. B. S.

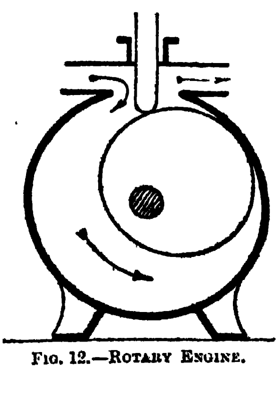


FIG. 12.—ROTARY ENGINE.

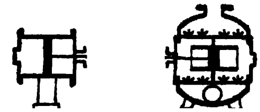


FIG. 13.—PUMPING ENGINE.

Steam Engine Indicator (*Eng.*) *See* INDICATOR DIAGRAMS.

Steam Gauge (*Eng.*) An instrument for measuring the pressure of steam. In the most usual form steam is admitted into a tube of elliptical section, closed at one end and bent into a circle; this tube tends to straighten out under the action of the pressure inside, and a certain amount of movement of the end of the tube is produced. This movement is transmitted to an indicating lever or arm, by

which it is magnified; the free end of the arm moves over a dial whose divisions show the actual pressure of the steam inside the bent tube.

Steam Hammer (*Eng.*) This consists essentially of a heavy mass of iron or steel, moving in vertical guides and raised by means of a rod and piston working in a steam cylinder placed vertically above the guides. The hammer is raised by means of steam admitted to the cylinder, and either falls by its own weight, or else the force of the blow is modified by admitting steam above or below the piston. So perfect is the control which a skilled man can exert over a steam hammer that a nut can be cracked on the anvil without injury to the kernel. Steam hammers are used in all heavy forging operations.

Steam Hammer Type (*Eng.*) An engine of the marine type, in which the framework resembles the form of a steam hammer. *See* STEAM ENGINES.

Steaming (*Eng.*) (1) Getting up steam in a boiler. (2) As applied to a steamship, propelled by its own engines. (3) In general language, giving off steam or vapour.

—— (*Textile Manufac.*) Process of blowing the cloth with steam after pressing, to take off the excessive gloss or glaze.

Steam Jacket (*Eng.*) A hollow casing round the cylinder of an engine. The space between the cylinder and the jacket is kept supplied with hot steam from the boiler, in order to maintain the temperature of the cylinder, and thus prevent condensation of the steam inside the latter.

Steam Jet (*Eng.*) A current of steam issuing from an opening or nozzle. It is used for various purposes: to supply water vapour in the production of various kinds of producer gas, to aid the production of draught through the furnace in locomotives, to clear noxious gases out of a well or shaft, etc.

Steam Joints (*Eng.*) Joints in engines, steam pipes, etc., which are rendered steam-tight by the use of suitable packing materials. The material used must be one which can be forced by pressure into the interstices of the joint, and which will not afterwards crack, shrink, nor decompose rapidly. Rubber, various fabrics, and soft metals, such as lead or copper wire, are used.

Steam Lap (*Eng.*) *See* SLIDE VALVE.

Steam Line (*Eng.*) The upper horizontal part of an INDICATOR DIAGRAM (*q.v.*), which shows the entrance of steam at uniform pressure.

Steam Nozzle (*Eng.*) The jet by which steam is discharged into the chimney of a locomotive, in order to increase the draught through the furnace.

Steam Passages (*Eng.*) The PORTS of a steam cylinder. *See* STEAM ENGINE *and* SLIDE VALVE.

Steam Pipes (*Eng.*) The pipes, of iron or copper, which lead steam from the boiler to the cylinder of an engine.

Steam Ports (*Eng.*) *See* STEAM ENGINE *and* SLIDE VALVE.

Steam Pressure. *See* STEAM.

Steam Reversing Gear (*Eng.*) A small subsidiary cylinder for actuating the gear which moves the slotted link in the valve gear of large engines that have to be reversed; it is chiefly employed in large marine engines.

Steam Space, Steam Room (*Eng.*) The space in a boiler which is not occupied by water. Its volume varies with the conditions under which steam has to be supplied.

Steam Tight (*Eng.*) A joint through which steam cannot leak when the material of the pipe, etc., is hot, is said to be steam-tight.

Steam Trap (*Eng.*) An arrangement for intercepting water which is carried over from the boiler by steam, or which is condensed in the pipes. In many forms of trap there is an automatic valve to allow the water to escape after a certain quantity has accumulated.

Steam Turbine (*Eng.*) *See* TURBINE, STEAM.

Steam Valve (*Eng.*) Any valve for controlling the flow of steam, *e.g.* a SLIDE VALVE (*q.v.*)

Steam Whistle. A whistle in which sonorous vibrations are set up by a sharp-edged sheet or tube of metal, on which a jet of live steam impinges.

Stearic Acid (*Chem.*) $CH_3.(CH_2)_{16}.COOH$. White shining plates or needles; melts at 69·2°; boils at 291° under 100 mm. pressure; insoluble in water; sparingly soluble in cold alcohol; much more soluble in hot alcohol; soluble in ether and benzene. Heated with phosphorus pentoxide it gives stearone $(C_{17}H_{35})_2CO$. Occurs as glyceryl ester, tristearin, in many animal and vegetable fats and oils. Its sodium salt is the chief constituent of good soap. It is made by melting and filtering beef or mutton suet, saponifying the suet by boiling with caustic soda solution; decomposing the soap with hydrochloric acid; crystallising from hot alcohol; the pressed crude acid is boiled with an alcohol solution of magnesium acetate, when a precipitate of magnesium stearate forms, which is decomposed by boiling with hydrochloric acid, and the stearic acid so obtained is crystallised from alcohol. *See* SOAP.

Stearin (*also called* TRISTEARIN) (*Chem.*) One of the chief constituents of all solid vegetable and animal fats. *See* FATS. It crystallises from ether in shining leaves. When heated it melts first at 55°, and undergoes contraction, and on further heating it solidifies, and melts again at 72°. Slightly soluble in cold alcohol; more soluble in hot alcohol; soluble in ether. Distils unchanged under reduced pressure. Ordinary stearin always contains tripalmitin. Pure stearin is made from monostearin,

$$C_3H_5 \begin{array}{l} O_2C_{18}H_{35} \\ OH \\ OH \end{array}$$

(from glycerine and stearic acid) by heating it with stearic acid in excess at 270°. Stearin is largely used for making fatty acids in candle making.

Steatite *or* **Soapstone** (*Geol.*) A hydrous magnesian silicate usually occurring in connection with beds of serpentine which have undergone dynamic metamorphism. Chromite, and also Magnetite, are not uncommonly associated with it. It may be regarded as a massive form of Talc.

Steel. The chemistry and metallurgy of steel are described under IRON; definitions are also given under this head of the chief varieties of steel, and of the various processes by which they are produced (*e.g.* OPEN HEARTH, SIEMENS-MARTIN, *and* BESSEMER PROCESS). The effect of the addition of various elements—*e.g.* manganese, chromium, and nickel—is also dealt with.

The employment of steel has increased very greatly in recent years. Originally its chief use was for cutting tools, weapons, springs, etc., where its properties of hardening and tempering were essential, and in all these respects steel still holds its position. It is in the use of CAST STEEL and MILD STEEL that the greatest progress has been made. Castings are largely made from steel produced by the Open Hearth Process (*see* IRON), the process differing but little from the ordinary method of making iron castings. Good steel castings are somewhat more difficult to produce than those of iron, and require annealing after withdrawal from the mould; they however, possess greater strength. MILD STEEL closely approaches wrought iron in composition and properties; like wrought iron, it can be welded, and cannot be hardened nor tempered. It can be used for practically all the purposes for which wrought iron is usually employed, *e.g.* plates for boilers, ships, girders, the production of thin sheets, drums, pipes, wire, rivets, and for a variety of electrical work.

Steel Castings (*Met., etc.*) *See* STEEL.

Steel Facing (*Eng.*) A layer or plate of steel welded on to the iron body of an anvil, hammer, etc., to produce a hard external surface.

Steel, Harveyised. *See* IRON (*Chem.*)

Steeling (*Eng.*) The operation of facing with steel. *See* STEEL FACING.

Steel, Mild. *See* IRON (*Chem.*)

Steel Ropes (*Eng.*) Ropes made of thin twisted steel wire. *See also* WIRE ROPES.

Steelyard. A device for weighing, consisting of a lever of the first kind: the object to be weighed is suspended from the short arm and a small movable weight is moved along the other arm (which is graduated) till the lever is in equilibrium. The weight is then read off on the graduated scale.

——, **Danish.** A modified form of steelyard in which a constant weight is fixed at one end, and the fulcrum is movable.

Steening, Steining, *or* **Steaning** (*Mining, etc.*) Lining the walls of a shaft or well with brickwork or masonry, in order to prevent irruption of the surrounding soil.

Steeple (*Architect.*) The tower of a church, together with its spire or lantern.

Steering. (1) Directing or guiding the motion of a vessel or vehicle. (2) Turning a crane, etc., about its vertical pivot; more often termed SLEWING (*q.v.*)

Steering Gear. (1) Mechanism for moving the rudder of a ship, the axle or steering wheels of a vehicle, etc. (2) The toothed wheels employed in slewing a crane.

Stele, Stela (*Architect. and Archæol.*) (1) An upright stone; the term generally denotes the Greek tombstone, which was usually a vertical slab tapering upwards and crowned with an ornament similar to an antefixa, and known as the stele crest, above a simple cornice. Stelæ were also used for public purposes, *e.g.* for displaying laws and decrees, or as boundary marks. They constitute interesting relics of Greek and Roman art, being often elaborately sculptured. *Cf.* CIPPUS. (2) The shaft or wooden part of an arrow, *i.e.* without feathers or head, was termed the stele.

Stencil *or* **Stencil Plate.** (1) A thin plate (usually of metal) having letters or other designs cut through it; by rubbing a brush charged with some kind of thick ink or paint over the plate the design can be reproduced on a surface against which the plate is held. (2) The letters or designs so produced.

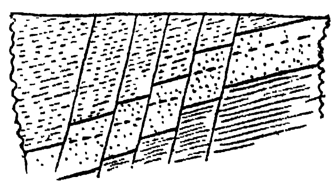
Stencilling (*Dec.*) The art of ornamenting by means of stencil patterns. Stencilling is usually done in distemper, but sometimes in oil colour, by means of a stiff brush, the stencil pattern being held in position by needle points. Frequently two or more colours are used in a stencil ornament, a different stencil being used for each colour. During the last few years stencilled friezes on paper and various textiles have come largely into use. These are prepared by some of the wallpaper manfacturers, and are usually executed in blended colours. The stencil plates being made of heavy copper, their weight is sufficient to hold the paper or texile in its place while stencilling is executed. A large brush filled with colour is employed, and, being pressed heavily upon the pattern, the colour is left very strong. When the brush is raised the colour becomes less well defined. Portable stencil decorations will doubtless remain popular for some considerable time.

Stenter (*Lace Manufac.*) An ingenious improvement in the principle of machinery for dressing lace curtains whereby it becomes a continuous process. The breadth of lace curtain having undergone the preliminary processes of colouring and starching, is fed into the stenter at one end in its wet state, and comes out at the other end thoroughly dried, stiffened, and calendered.

Stenter Feeder. One of the operatives who manipulates the clips that grasp the selvages of the lace curtain as it enters the stenter (*q.v.*)

Step (*Eng.*) (1) A FOOTSTEP BEARING (*q.v.*) (2) The difference between the radii of consecutive pulleys forming a stepped or coned pulley.

Step Faults (*Geol.*) The dislocation accompanying a fault is rarely quite simple in character. More often the disruption is the cumulative effect of a number of small faults running parallel to each other, and having a common direction of downthrow; so that their traces, when seen in elevation, appear like steps.

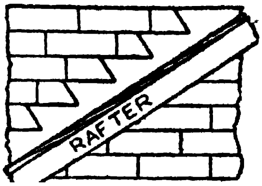


STEP FAULT.

Stephanite (*Min.*) A silver sulph-antimonide, $5Ag_2S.Sb_2S_3$; silver=68·5, antimony=15·3, sulphur =16·2 per cent. Orthorhombic, often massive in indefinite masses scattered through the matrix; colour iron black, with metallic lustre. From many silver mines of Central Europe in small quantity; from Mexico, Peru, etc.

Steppe Conditions (*Geol.*) Desert conditions (*q.v.*) such as those which occur in the elevated tracts of Central Asia.

Stepped Flashing (*Plumb.*) Lead or zinc cut in the form of steps and pinned into the joints at the angle where a roof meets a wall.



STEPPED FLASHING.

Stepped Gearing (*Eng.*) Toothed wheels in which there are two or more parallel rows of teeth, the teeth in the second row being slightly in front of those in the first, and so on. A tooth in any one row comes into action before the corresponding one in the previous row is completely disengaged, and thereby the relative motion of the two wheels is made more steady and the stresses less violent than in ordinary gearing.

Stepped Resistance (*Elect.*) An electrical resisttance which can be increased or diminished by definite amounts at a time; usually composed of a number of coils in series, so connected that one, two, three, etc., may be included in the circuit at will.

Stepping Round (*Eng., etc.*) Dividing the circumference of a circle into a number of equal parts, by means of dividers or compasses.

Steps, Balanced (*Carp. and Join.*) *See* BALANCED STEPS.

Step Up Transformer (*Elect. Eng.*) A transformer in which the induced or secondary E.M.F. is greater than the primary E.M.F. *See* TRANSFORMERS.

Stère. *See* WEIGHTS AND MEASURES.

Stereo (*Print.*) An abbreviation of the word STEREOTYPE (*q.v.*)

Stereochemistry. As chemical formulæ are ordinarily written, it would appear as if all the atoms which go to form the molecule of a compound are in one plane. This is probably never the case. Consider the compound methylene chloride (CH_2Cl_2): if all the atoms lie in one plane, we should have two compounds of this formula,

$$\begin{array}{c} H \\ | \\ H-C-Cl \\ | \\ Cl \end{array} \text{ and } \begin{array}{c} Cl \\ | \\ H-C-H, \\ | \\ Cl \end{array}$$

whereas only one compound is known. That only one compound of the formula CH_2Cl_2 exists is accounted for by assuming that the carbon atom occupies the centre of a regular tetrahedron, while the four atoms in union with it are attached at the angular points. The same assumption is made to explain the optical behaviour of compounds which contain an asymmetric carbon atom (*see* ASYMMETRIC CARBON ATOM); and a similar assumption is made to explain the optical behaviour of certain selenium, sulphur, and tin compounds. *See* the respective elements. The determination of the arrangement of the atoms of a molecule in space and the solution of certain problems arising out of this is called Stereochemistry. One important problem of Stereochemistry is that of Stereoisomerism (*q.v.*) The other problems relate to the influence which the space-arrangement of the various atoms or groups in a molecule exercises on the course of reactions. A few examples are added. Let a series of tetrahedra be joined together in such a way that the centres of the first and second are in a straight line, the centres of the second and third in a straight line, and so on; then it will be found that of all the tetrahedra up to five the angular points of the first and fifth are nearest together, and if a sixth tetrahedron is added, its free angular points will be nearer to those of the first one than any of the others, except the fifth. Corresponding to this is the ease of formation and stability of five and six carbon atom ring compounds. Thus, on distilling the sodium salts of the homologues of the oxalic acid series, the first member to give a ring compound, molecule for molecule is adipic acid.

$$CH_2\begin{array}{l} \diagup CH_2.COONa \\ \diagdown CH_2.CH_2.COONa \end{array} = CH_2\begin{array}{l} \diagup CH_2.CO \\ \diagdown CH_2.CH_2 \end{array}\Big| + CO(ONa)_2.$$

Ketopentamethylene.

Pimelic acid gives ketohexamethylene.

$$CH_2\begin{array}{l} \diagup CH_2-CH_2.COONa \\ \diagdown CH_2-CH_2.COONa \end{array} = CH_2\begin{array}{l} \diagup CH_2-CH_2 \\ \diagdown CH_2-CH_2 \end{array}\!\!>CO + CO(ONa)_2.$$

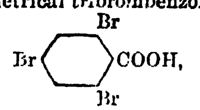
In the same way the easy formation of γ- and δ-lactones may be explained.

In the conversion of the following acids

$$\begin{array}{c} H \\ | \\ H-C-H \\ | \\ COOH \end{array} \quad \begin{array}{c} H \\ | \\ H-C-CH_3 \\ | \\ COOH \end{array} \quad \begin{array}{c} CH_3 \\ | \\ H-C-CH_3 \\ | \\ COOH \end{array} \quad \begin{array}{c} CH_3 \\ | \\ H_3C-C-CH_3 \\ | \\ COOH \end{array}$$

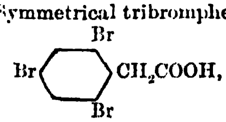
into esters there is a diminution in the speed of the reaction from left to right, acetic acid forming an ester at a higher rate than propionic, etc. This is to be attributed to the fact that the space round the carboxyl group is less filled in the case of acetic acid than in that of propionic acid, and so on; and therefore the entrance of the alkyl group is more and more difficult as we proceed from acetic to trimethylacetic acid. Again, triphenylacetic acid esterifies much more slowly than diphenylacetic acid. In the benzene series the ortho-positions play the same part as the α-position in the above series of acids, as is shown by the following example:—

Symmetrical tribrombenzoic acid,



gives no ester.

Symmetrical tribromphenylacetic acid,



gives 99 per cent. ester.

Just as ester formation is retarded, so also is the process of hydrolysis. An example of this kind is given under NITRILES (*q.v.*) Nitrogen compounds furnish good examples of this steric hindrance to reaction: aniline is a weak base, but forms many salts; diphenylamine forms very few salts; triphenylamine forms no salts; tetraphenylammonium compounds do not exist. The following example clearly shows that the addition of alkyl iodide cannot take place for want of space in benzyldiphenylamine:—

$$\begin{array}{l} C_6H_5 \\ | \\ N-CH_2C_6H_5 \\ | \\ C_6H_5 \end{array} \text{ will not combine with methyl iodide.}$$

Benzyldiphenylamine.

$CH_2C_6H_5$
|
$N-CH_2C_6H_5$ combines with difficulty with methyl iodide.
|
C_6H_5
Dibenzylaniline.

$CH_2C_6H_5$
|
$N-CH_2C_6H_5$ combines readily with methyl iodide.
|
$CH_2C_6H_5$
Tribenzylamine.

See also under SEMIDINE TRANSFORMATION.

Stereography (*Art*). The art of drawing solid bodies on a plane surface: perspective.

Stereoisomerism (*Chem.*) Isomerism caused by a difference in the arrangement in space only, of the same atoms or groups of atoms in a molecule, their mode of union remaining the same. The compounds

$$\begin{array}{ccc} CH_2Cl & & CH_3 \\ | & \text{and} & | \\ CH_2Cl & & CHCl_2 \\ \text{Ethylene chloride.} & & \text{Ethylidene chloride.} \end{array}$$

are isomeric, but not stereoisomeric, because the mode of union of the chlorine atoms is not the same, there being one united to each carbon atom in ethylene chloride and two united to the same carbon atom in ethylidene chloride. The two forms of

$$\begin{array}{c} CH_2COOH \\ | \\ H-C^*-COOH \\ | \\ OH \end{array}$$

malic acid, namely, dextrorotatory and lævorotatory, are stereoisomers, because in both we have the same atoms and groups of atoms similarly combined, but there is a difference in the space arrangement of the four groups attached to the carbon atom marked *. The elements which form stereoisomeric compounds are carbon, sulphur, selenium, tin, nitrogen; the explanation of this property in the case of carbon is given by the theory of the asymmetric carbon atom. *See* ASYMMETRIC CARBON ATOM. A similar explanation is given for sulphur, selenium and tin, but no generally accepted explanation for nitrogen has been offered yet. Examples of compounds containing one asymmetric carbon atom are: lactic acid, mandelic acid, amyl alcohol, malic acid, pinene, leucine. *See all these.* For sulphur, selenium, tin, *see under* the respective elements. When there is only one asymmetric atom in a compound, the latter is known in three forms, namely, the dextrorotatory form, the lævorotatory form, and an optically inactive form obtained by mixing equal quantities of the dextro- and lævo-forms. When there are two asymmetric carbon atoms in a compound, more than three forms can exist; denoting the two carbon atoms by A and B and the dextro arrangement of A by $+A$, the lævo arrangement by $-A$, and similarly for B we have the following forms:

$$\begin{array}{cccc} +A & +A & -A & -A \\ +B & -B & +B & -B \end{array}$$

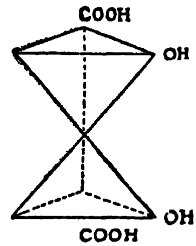
without counting racemic forms, of which there will be two. Suppose the same groups are attached to each carbon atom, then we have:

$$\begin{array}{cccc} +A & +A & -A & -A \\ +A & -A & +A & -B \end{array}$$

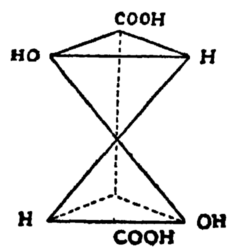
In this case there are three forms only, not counting the single racemic form, because the two middle arrangements are identical. The $\begin{smallmatrix} +A \\ -A \end{smallmatrix}$ arrangement is optically inactive because the dextrorotatory power of the one half of the molecule is compensated by the lævorotatory power of the other half of the molecule. This kind of compound is said to be inactive by internal compensation; it is also called a meso-compound. An example of each of these two classes of two asymmetric carbon atom compounds is given:

$$\begin{array}{ccc} CH_2OH & & COOH \\ | & & | \\ H-C-OH & & H-C-OH \\ | & & | \\ H-C-OH & & H-C-OH \\ | & & | \\ CHO & & COOH \\ \text{A four carbon-atom sugar.} & & \text{Tartaric acid.} \end{array}$$

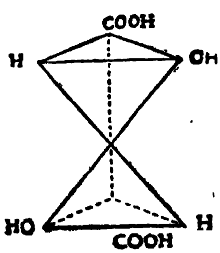
The tetrahedral formula for tartaric acid may be written



To decide which form of tartaric acid is represented by the diagram, let a plane be drawn through the common angular point and parallel to the opposite faces of the tetrahedra; then if the plane divide the figure symmetrically the compound is inactive; thus the above figure represents mesotartaric acid. By interchanging any two groups in the upper tetrahedron we get



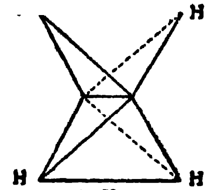
which is lævotartaric acid if the upper tetrahedron in the first formula was dextrorotatory; similarly, if any two groups in the lower tetrahedron in the first formula (assuming the upper one to be dextrorotatory) were interchanged, we should have



which would be dextrotartaric acid. Instead of drawing tetrahedra we may represent the formulæ of these compounds by supposing the groups to be projected on to the plane of the paper, and this is commonly done to save space. Thus we may represent the tartaric acids as follows:

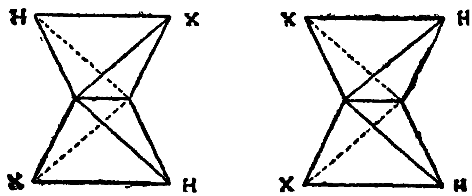
Dextrotartaric acid.	Lævotartaric acid.	Mesotartaric acid.
COOH	COOH	COOH
|	|	|
H—C—OH	HO—C—H	H—C—OH
|	|	|
HO—C—H	H—C—OH	H—C—OH
|	|	|
COOH	COOH	COOH

Racemic tartaric acid, commonly called racemic acid, is formed from equal quantities of the dextro- and lævo-acids. The five and six carbon atom sugars furnish examples of carbon compounds which contain more than two asymmetric carbon atoms. When equal quantities of dextro- and lævo-modifications of the same substance are mixed, the resulting inactive product may, in the case of solids, be a mere mixture of the two substances, or mixed crystals may be obtained, or chemical union may occur, and a true racemic compound be formed. Chemical reaction will not distinguish between the three cases; they are distinguished by their behaviour on melting and solution. The inactive mixture will melt below either of its components or any other mixture of them, and addition of either component to it will raise its melting point; the racemic compound will have a melting point either above or below that of its components, but addition of either component will lower it till a certain excess is added, when it will raise the melting point. In the case of the inactive mixed crystal this may melt at the same temperature as its components, or behave as the inactive mixture, or have a melting point above that of its components, in which last case addition of either component will lower it constantly to the melting point of its components. As a racemic compound may only be stable through a limited range of temperature, the melting point determination only gives information as to the state of the substances about the melting point. Hence solubility determinations are important. To distinguish between an inactive mixture and a racemic compound a saturated solution is made at a given temperature with the inactive compound, and another saturated solution at the same temperature is made with the inactive substance plus one component. In the case of the mixture both solutions will be identical and inactive; in the case of the racemic compound one will be inactive and the other active. As an example may be given sodium ammonium tartrate, which will be found to form an inactive mixture if crystallised below 28°, but a racemic compound if crystallised above 28°. When compounds containing asymmetric atoms of any kind are synthesised, the inactive form is always obtained. These inactive forms can be resolved into their components: (1) by the use of ferments of various kinds, (2) by the use of other optically active substances, (3) by taking advantage of a difference in the speed of esterification. For examples, see under the individual substances mentioned before. Another kind of space isomerism called geometrical isomerism is found in cases where two carbon atoms are united by a double linking, as they are in ethylene. On the theory of the tetrahedal carbon atom, ethylene is represented by the following formula, in which the tetrahedra are represented as united along an edge:



C_2H_4

This formula would lead us to expect that if one hydrogen atom of each carbon were replaced by another atom, or group X, two isomers would exist having the formulæ:



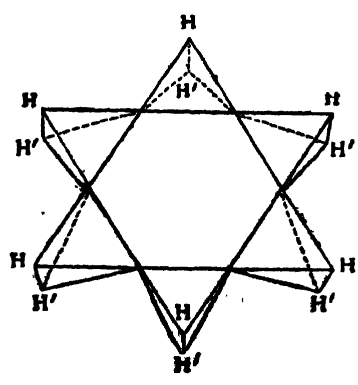
For shortness these formulæ are usually abbreviated thus:

I	II
H—C—X	H—C—X
H—C—X	X—C—H

The first example of this kind of isomerism to be discovered is that of Fumaric and Maleic Acids (*see these*):

Fumaric acid.	Maleic acid.
H—C—COOH	H—C—COOH
HOOC—C—H	H—C—COOH

To distinguish isomers of this kind, that isomer having the formula I is called the Cis or Maleinoid compound, and that having the formula II is called the Trans or Fumaroid compound. The cis-formula is assigned to maleic acid, chiefly because it readily forms an anhydride, while fumaric acid does not. Other examples of compounds showing this kind of isomerism are cinnamic acid, crotonic acid, stilbene. *See these.* Another kind of cis- and trans-isomers occurs in certain ring compounds. Let six tetrahedral carbon atoms be joined as in the figure



Now imagine a plane passing through the centres of the six tetrahedra, that is, through the carbon atoms, then the six hydrogen atoms marked H are above this plane, and the six hydrogen atoms marked H' are below it. Replace the H atom from one tetrahedron and the H' from an opposite tetrahedron by carboxyl groups. The two dicarboxylic acids so obtained are stereoisomers. The first is cis-hexahydroterephthalic acid, and the other is trans-hexahydroterephthalic acid. From the diagram it is seen that the relationship between them is similar to that between fumaric and maleic acids, the edges of the tetrahedra concerned only being separated from each other in the case of the hexahydroterephthalic acids by the intervening pairs of tetrahedra. One of these hexahydroterephthalic acids closely resembles fumaric acid and the other maleic, and that which resembles fumaric is regarded as the trans-acid and the other as the cis-acid.

Trans-Acid.	*Fumaric Acid.*
Sublimes on heating.	Sublimes on heating.
Crystallises in small prisms.	Crystallises in small prisms.
Sparingly soluble in water.	Sparingly soluble in water.
Cis-Acid.	*Maleic Acid.*
Melts at 160°.	Melts at 130°.
Crystallises in large crystals.	Crystallises in large crystals.
Much more soluble in water than the trans-acid.	Much more soluble in water than fumaric acid.

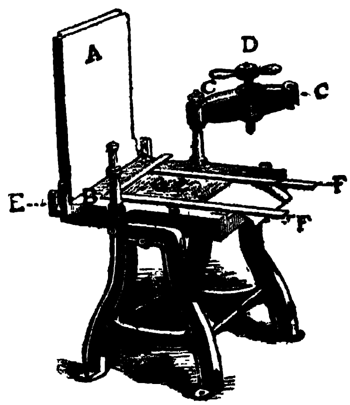
Both sets of acids are mutually convertible into each other. Unlike maleic acid, the cis-hexahydroterephthalic acid does not form an anhydride, as might be expected from the greater distance between the carboxyl groups. *See* PHTHALIC *and* TEREPHTHALIC ACIDS. For stereoisomerism of nitrogen *see* OXIMES *and* QUATERNARY AMMONIUM COMPOUNDS.

Stereometer (*Phys.*) A VOLUMENOMETER (*q.v.*)

Stereotype (*Typog.*) A cast in metal of the printing surface of a page of type. The earliest stereotypes in existence are said to have been produced about the year 1700; but as they were formed, by soldering the bottoms of types together with some metal substance, there is a doubt as to their right to the appellation. Not only was re-composition necessary when duplicates were required, but the type was put out of use for other purposes. The process proper was first practised by William Ged, a goldsmith of Edinburgh, about the year 1725, under circumstances of great difficulty, the operative printers of the time being opposed to the innovation. The secret of his methods is not known, and was lost after the death of his sons. In 1801 a patent was taken out for producing stereotypes by the plaster of Paris process. Later, through the influence of Earl Stanhope, the idea was perfected, and the process was almost universal in this country until the French or *papier maché* system partially superseded it in 1850.

The PLASTER PROCESS requires a comparatively large plant, and is to some extent uncertain in its results. The forme of type, when prepared, is placed on an inclined slab fitted within a sink. A mixture of plaster of Paris and water is poured over it, and smoothed by the hand until all the interstices of the forme are filled up. The surface is then rubbed with a hard brush until the face and shoulders of the type appear, water flowing evenly over it during the process. After being allowed to dry partially, it receives a top dressing of soap and water, and is then lightly oiled by means of a soft brush. A flask, similar in form to a chase with bevelled edges, is then placed over the forme, and plaster of Paris mixed with water to the consistency of thick cream is poured on until the chase is full. It is then beaten and rolled until the mixture is level with the edges of the chase. When properly set, this is lifted from the forme, the mould is cut out of the chase, trimmed, and put into a baking oven. It is afterwards placed face downwards in the casting box; a lid with openings at each of the corners is placed on top, fastened with a screw, and immersed in a pot of molten metal. When the box is filled, it is withdrawn and cooled. The lid is then removed, the plates knocked out, relieved of the plaster, and trimmed.

The PAPER PROCESS consists of four parts: *i.e.* the composition of the flong (*q.v.*), the preparation of the matrix, the casting of the plate, and the finishing process. The pages of type are prepared by having metal clumps of the same height placed round their outer edges. The flong when made is laid on the type, tissue downwards, and covered with a damp linen cloth. It is then beaten with a hard flat brush until the form of the type is noticeable. A thick piece of coarse paper is next pasted on, and the beating process repeated. The forme, with the mould or matrix in position, is then placed on the hollow bed or steam box of a drying press, covered with a thick blanket, and pushed beneath the platen of the press, which is screwed down. After remaining in this position for ten or fifteen minutes, the mould is removed, trimmed, furnished at one end with a strip of brown paper, and placed on the steam chamber of the press, where it remains until thoroughly hardened. Weights are placed along the edges of the mould to keep it perfectly flat. After the face has been dusted with fine French chalk, it is transferred to the casting box, which consists of two flat iron surfaces, the top one (A) serving as a lid. Both are loosely hinged together at the bottom (E), so that plates of different thicknesses may be cast as necessary. The two surfaces of the box are held firmly in position by a swinging bar (CC), which clamps them together by means of a centre screw (D). The mould (G) is laid on the lower plate (BB), with the strip of paper already referred to lying loose at the top when the box is tilted to a vertical position, thus forming a lip to guide the molten metal in its course over the face of the mould between the two flat surfaces. Lying along the edges of the mould are gauges (FF), which determine the thickness of the plate being cast.



STEREO CASTING BOX WITH UPPER SURFACE RAISED AND MOULD IN POSITION.

Several plates may be produced from the same mould A few seconds after the metal has been poured, the box is returned to its horizontal position, the screw loosened, and the upper plate or lid is raised. The plate can then be removed for trimming and finishing. The tang, or piece of superfluous metal, is sawn off, the edges are roughly trimmed, and the backs planed to ensure all plates being of uniform height. Open spaces are chiselled or chipped out, to prevent any

but the necessary parts printing on the paper, and the edges are bevelled. The plates are then ready for placing or fixing on beds or mounts, to render them uniform in height with ordinary type. The processes described refer particularly to stereotypes for flat bed printing. For rotary printing the matrix or mould is placed in a box curved to suit the cylinder of the special class of printing machine, the plates, when cast, being practically semicircular in form. There are also other systems, in which specially prepared flongs are used in a dry state.

Sterilisation (*Biology*). (1) In general terms, the destruction of the power of reproduction possessed by a living organism. (2) The destruction of organisms, especially bacteria (*q.v.*) and their spores.

Stern Tube (*Eng.*) The tube in which the end of the shaft of a screw propeller is carried through the stern of a ship.

Stern Wheel Steamers (*Eng.*) *See* AMERICAN RIVER STEAMERS.

Sterro Metal (*Met.*) A form of brass, with which 4 to 5 per cent. of iron is alloyed: it is remarkable for its strength, and was used for ordnance in Austria.

Stet (*Typog.*) *See* PRESS CORRECTIONS.

Stevenson's Screen (*Meteorol.*) *See* THERMOMETER SCREEN.

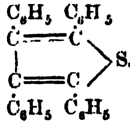
Stibnite (*Min.*) Sulphide of antimony, Sb_2S_3; antimony = 71·8, sulphur = 28·2 per cent. Orthorhombic in long crystals striated longitudinally. Colour steely grey. It is the most important ore of antimony. It is used, along with Galena, in the East to darken the under surface of the eyelids. From Cornwall, Ayrshire, Hungary, Borneo, but chiefly now from Japan, whence come fine crystals.

Sticker (*Music*). A thin rigid piece of wood used in the mechanism of the organ for pushing up certain parts. It is held in position by a wire inserted at each end through holes in the levers. *See* ORGAN, p. 439. *Cf.* TRACKER.

Stiff Leaf Foliage (*Architect.*) The conventional foliage used in Early English (*q.v.*) architecture, particularly that used in the capitals.

Stigmatic Lens (*Light*). If light diverging from a point is exactly focussed at a second point by a lens, then the lens is truly STIGMATIC. This term, though convenient, is rarely used.

Stilbene (*Chem.*) $\begin{matrix} CHC_6H_5 \\ \| \\ CHC_6H_5 \end{matrix}$ (Also called symmetrical diphenylethylene and toluylene.) Stilbene and many of its derivatives can exist in two stereo-isomeric forms, $\begin{matrix} H—C—C_6H_5 \\ \| \\ C_6H_5—C—H \end{matrix}$ and $\begin{matrix} H—C—C_6H_5 \\ \| \\ H—C—C_6H_5 \end{matrix}$ Ordinary Stilbene has probably the latter formula: it is a white solid crystallising in large monoclinic plates; melts at 124°; boils at 306°; sparingly soluble in cold alcohol, much more soluble in hot; soluble in ether and benzene; distils in steam. Its vapour passed through a redhot tube gives anthracene and toluene. On reduction by heating with hydriodic acid it gives dibenzyl, $\begin{matrix} CH_2.C_6H_5 \\ | \\ CH_2.C_6H_5 \end{matrix}$. With bromine it gives a dibromide. On prolonged heating with sulphur it gives tetraphenylthiophene,



S. Stilbene is obtained (1) by heating benzaldehyde or benzalchloride with sodium,

$$2C_6H_5CHCl_2 + 4Na = \begin{matrix} C_6H_5.CH \\ \| \\ C_6H_5\ CH \end{matrix} + 4NaCl.$$

(2) By heating phenyl fumarate,

$C_6H_5OOC.C.H$ $C_6H_5.C.H$

$H.\ddot{C}.COOC_6H_5$

Phenyl cinnamate.

(3) By heating β-trithiobenzaldehyde (obtained by passing hydrogen sulphide into a mixture of benzaldehyde and alcoholic hydrochloric acid) with copper. A few stilbene derivatives are dyes, but they are not obtained directly from stilbene.

Stilbite (*Min.*) A hydrous calcium aluminium silicate, $6H_2O, (Na_2Ca)O, Al_2O_3.6SiO_2$. Monosymmetric, in complex fourlings appearing as one crystal. Colour white, or rarely red. Pearly lustre. Dumbarton and Stirlingshire in Scotland; the Giants' Causeway; Faroë Island; India, etc.

Still Life (*Art*). A picture representing flowers, fruit, furniture, and inanimate objects generally. The Dutch School are famous for their pictures of STILL LIFE.

Stipple, Stippled (*Engrav.*) *See* ENGRAVING AND ETCHING, p. 201.

—— (*Paint.*) A method of painting in which effect is obtained by means of series of dots instead of by strokes or flat tints.

Stippler (*Dec.*) *See* PAINTERS' BRUSHES.

Stirrup (*Eng.*) The name applied to a piece of metal in the form of a loop resembling a stirrup, sometimes used in mechanism.

Stitching (*Bind.*) The term used for the method of sewing a pamphlet (or pamphlet and cover) when it consists of a single section or sheet. The sheet is opened out and sewn through the middle, the thread being cut and the ends tied together in the centre. *See* WIRE STITCHING.

Stoa (*Architect.*) A Greek term usually employed to denote a portico (*q.v.*) The Greek portico was often detached and of considerable extent. It afforded shelter while walking.

Stock (*Archæol.*) (1) The portion of a tally (generally a notched stick) which a creditor retained as evidence of the king's debt. The counterstock was retained in the Exchequer. (2) A band of leather or other stiff material, sometimes covered with a soft fabric, worn in place of a cravat.

—— (*Eng.*) (1) A general term for part of a machine or device which supports or contains an operating part or a part on which work is actually performed, *e.g.* the support of an anvil. *See* HEAD STOCK (*Eng.*) *and* STOCKS AND DIES. (2) The mass of heated coal not yet ignited surrounding the hot part of a smith's fire.

—— (*Her.*) A bearing consisting of the stump of a tree cut off square at the top and eradicated at the roots, the main roots being shown.

Stockingette Cloth (*Textile Manufac.*) May be either knitting which is the original stockingette, or woven in the ordinary way, what is termed a "stockingette" weave being used.

Stock Rail (*Eng.*) The fixed rail which is fitted at points (*q.v.*) in a railway, as distinguished from the hinged rail or point proper. *See under* RAILWAYS.

Stocks. Bricks burnt in a clamp. *See* BRICKS.

—— (*Archæol.*) A device for punishing petty offenders. It consisted of a heavy wooden frame with movable planks placed horizontally on edge, the latter being pierced with holes for confining the legs or arms or both.

—— (*Civil Eng.*) The massive timbers on which a ship rests while being built.

—— (*Woollen Manufac.*) An old form of fulling or felting (*q.v.*) Usually the machine consists of a pair of stocks, but they have also been made with only one stock foot, and with three. In the older form of the machine the stocks are allowed to fall on the material by gravity; in the newer form they are controlled by crank gearing, and the length of the traverse can be diminished or lengthened as required.

Stocks and Dies (*Eng., etc.*) Tools used for cutting external or "male" threads. The die consists essentially of a hardened steel nut, which is usually divided into two parts, the ends of the threads where they are cut across serving as cutting edges for producing the new thread which is to be cut. The STOCK is a suitable holder for the dies, commonly with a screw by means of which the distance apart of the two halves of the nut may be adjusted, and two straight handles by means of which it is turned in order to produce the thread. When commencing to cut a thread the two halves of the die are separated to such a distance that they will just allow the blank on which the thread is to be cut to enter; the stock is then turned and the dies gradually cut a thread, which is deepened by screwing the dies closer together after each cut.

Stocks, Grey, *and* **London.** *See* BRICKS.

Stokehold (*Eng.*) A term commonly used in marine practice as the equivalent of "boiler house"; the place in which the stoking of the boilers is carried on.

Stokehole (*Eng.*) (1) A pit or other space in or from which stoking is carried on. The space allotted to the stokers or firemen in a steamship for supplying fuel to the furnaces is usually sermed a stokehold (*q.v.*) (2) A hole in a reverberatory furnace for introduring a rabble (*q.v.*) or other tool.

Stoking (*Eng.*) Putting fuel into a furnace, etc., removing clinkers, and generally attending to the fire.

Stola (*Archæol.*) The outer garment worn by the Roman matron. *Cf.* PALLA.

Stole (*Cost.*) A narrow band, fringed at the ends, worn by the clergy over the shoulders.

Stomata (*Botany*). Minute openings in the epidermis of leaves and other green parts of a plant concerned in gaseous interchange between the tissues and the atmosphere. Special "guard cells" surround an opening which leads to the intercellular spaces of the leaf.

Stone Age. The Prehistoric Period during which Early Man shaped and used implements of stone. It is usually regarded as divisible into two periods:—an Earlier or Palæolithic, during which rudely shaped and unpolished stone implements were used, and a Later or Neolithic, at which time a more carefully finished type was used. The Earlier Stone Age may have lasted all through the Glacial Period, while the Later is certainly posterior in date to the Age of Snow.

Stoneware. A species of hard glazed pottery composed of silicious clay; or of clay and flint which has been ground and calcined, mixed in proper proportions. The glaze is effected by means of common salt, which is thrown into the furnace in which the ware is baked. *See* POTTERY.

Stool (*Build.*) The small surface worked on a stone sill to form a butt joint for the mullion.

Stoop. (1) A flagon or large cup for holding liquor. (2) A low platform or a portico in front of a house.

Stop. A very general term for a piece of metal or other material used to fill up some cavity, or to limit or check the motion of some piece of mechanism.

—— (*Build.*) The termination of a chamfer when it is not worked the whole length of a stone.

—— (*Carp. and Join., etc.*) (1) A projecting piece of wood or metal, used to keep a piece of wood from sliding along the bench when being planed. (2) One of the pieces of wood fastened to the frame of a door to form a recess into which the door shuts.

—— (*Music*). (1) A set of pipes in an organ. (2) Each knob by which the organist puts into action the various sliders. Properly known as a Draw stop. *See* MUSICAL INSTRUMENTS, p. 439.

Stop Cock (*Build.*) A cock or tap fixed near the main pipe to turn on or shut off the supply of gas or water in a house.

—— (*Eng.*) A term often applied to any cock or tap.

Stope (*Mining*). The parts of a mine between two levels, from which the ore is obtained in workings usually having the form of steps. OVERHAND STOPING consists in working from the under side, when the steps have the appearance of the under side of a staircase; in UNDERHAND STOPING the men work while actually standing on the steps.

Stoping (*Mining*). The excavation of minerals in steps, either above or below a certain level. OVERHAND STOPING: Excavating in an upward direction, the usual method. UNDERHAND STOPING: Excavating in a downward direction. *See also* STOPE.

Stopped Pipe (*Music*). An organ pipe having the upper end closed either by a STOPPER (*q.v.*) or metal cap. A stopped pipe gives a sound an octave lower than an open pipe. This is spoken of as so many feet tone; *e.g.* stopped diapason 8 ft. tone gives the same pitch as the open diapason 8 ft. In the former case the lowest pipe is 4 ft. long, in the latter 8 ft. long.

Stopper (*Glass Manufac.*) A slab of fireclay used for temporarily stopping up the mouth of the pot (*q.v.*) during founding.

—— (*Music*). The wooden plug inserted at the top of certain organ pipes, which causes the sound produced to be an octave lower than when unstopped (open).

Stoppering (*Met.*) Closing up the opening of the mould used for casting steel ingots, in order to prevent the action of the air on the fluid metal.

Stopping (*Build., Dec., etc.*) A substance, *e.g.* a mixture of size and whiting, used for filling nail-holes, shakes, cracks and flaws, etc., in the surface of work which has to present a smooth and finished appearance. *Cf.* BEAUMONTAGE.

—— (*Music*). The pressing of the fingers on the strings of stringed instruments to obtain other sounds than those given by the open strings (*q.v.*) When two notes are produced at once in this way, *i.e.* by stopping two strings, it is termed DOUBLE STOPPING.

Stopping Knife (*Dec.*) A knife used by painters for stopping nail-holes, etc., with putty.

Stopping Off (*Foundry*). Closing or filling up part of a mould in order to modify the size or shape of the casting.

Stopping Out (*Etching*). Covering with lamp-black, or other acid-resisting substance, certain portions of a plate which is being etched in order to prevent further etching of those parts. *See* ENGRAVING AND ETCHING *and* PHOTO-ENGRAVING.

Stop Valve (*Eng.*) A STOP COCK (*q.v.*)

Stop Watch (*Clocks and Watches*). A watch whose mechanism can be stopped or started at will by pressing a projecting stud. The most convenient type possesses separate mechanism, furnished with special indicating hands, capable of being stopped or started at any time without interference with the ordinary movement. One of these hands usually makes one complete revolution per minute, and indicates to the fifth of a second, while a second or smaller hand records the minutes completed since the watch was started.

Stop Work (*Clocks and Watches*). The arrangement limiting the amount of winding up permitted to the weight or mainspring.

Storage Battery (*Elect.*) A set of storage cells or accumulators (*q.v.*).

Storage Cell (*Elect.*) An ACCUMULATOR (*q.v.*).

Storm (*Meteorol.*) A violent commotion of the atmosphere, occurring in all climates and differing from other atmospheric disturbances in its destructive power and the extent over which it spreads.

Storm Beach (*Geol.*) The maritime zone along which the direct effects of the sea are manifested only during heavy gales. In general terms it may be said to range along the shore to a short distance inland from high-water mark.

Storm, Magnetic. Irregular or exceptional variations in the earth's magnetic element.

Storm Warnings (*Meteorol.*) Notices, telegraphed or published, predicting the approach of storms from the behaviour of the barometer or other instruments.

Storm Waves (*Meteorol.*) Exceptionally high waves occasioned by low atmospheric pressure during storms. Rendered more severe when occurring at high water and violent wind.

Story Rod (*Carp. and Join.*) A long stick used for setting out stairs, *e.g.* for measuring the vertical height from floor to floor.

Stoup. *See* STOOP.

Stourbridge Clay. A fireclay occurring in the Coal Measures at Stourbridge and elsewhere; it contains but little iron and very little lime or alkali. As it is very refractory, and can be heated to very high temperatures without melting or becoming pasty, it is much used for firebricks, crucibles, etc.

Stove. (1) A term loosely applied both to open fireplaces and to stoves proper, which are closed chambers. *See* STOVES. (2) A form of oven used for drying, enamelling, and many other purposes.

Stoves (*Hygiene*). Are commonly made of cast iron, the smoke and products of combustion escaping by an iron flue to the chimney or outer air, while the main portion of the heat radiates in all directions round the stove. This is a more economical but less healthy mode of heating than by an open fireplace, the ventilating power being less. There are three chief objections to the use of stoves: (1) They render the air hot and dry; this may be in a measure obviated by placing a vessel of water on the stove. (2) The escape of carbon monoxide through the walls of the stove; this objection may be overcome by lining the stove with firebrick and casing it with tiles, as is done on the Continent. (3) The bad smell sometimes caused by the decomposition of organic matters present in the air, due to their contact with the heated surface of the stoves.

Stove Screw (*Build.*) A screw with the thread cut close up to the head, used in fitting together the parts of stoves.

Straight Arch (*Build.*) See CAMBER ARCH.

Straight Edge (*Eng., Carp., etc.*) A flat rod of wood or metal; the edge is used for testing the accuracy of straight lines or plane surfaces.

Straight Pass (*Textile Manufac.*) *See* ENTERING.

Strain (*Phys., Eng., etc.*) A change in the dimensions or form of a body, produced by the action of forces termed STRESSES. Various kinds of strains are defined under ELASTICITY (*q.v.*)

Strainer (*Eng.*) A perforated cover attached to the end of the suction pipe of a pump, to prevent the entry of pieces of material which would obstruct the valves.

Straining (*Leather Manufac.*) The stretching or straining of skins in their wet state by nailing them out on frames and drying them in this strained condition, thus preventing contraction.

Straining Beam (*Carp. and Join.*) The horizontal timber that extends between the heads of the queen posts. *See* ROOFS.

Strain Slip Cleavage (*Geol.*) A structure developed in certain rocks by dynamic metamorphism. Intense lateral pressure, such as that exerted during the upheaval of great mountain masses, throws the finer laminæ of a stratified rock into minute puckers, which fracture at their crests and troughs, and eventually slip, or become faulted, on a very minute scale, along parallel planes which lie nearly at right angles to the direction of the pressure. A rock so affected is said to be sheared. If new minerals are developed along the planes of slip the rock becomes a SCHIST.

Straits Tin (*Met.*) Tin from the Straits Settlements—*e.g.* the Malay Peninsula, the islands of Banca and Bilitong, etc.; usually considered one of the very best varieties obtainable.

Strait Work (*Mining*). *See under* MINING.

Strake (*Mining*). A sloping board used in sorting gold ore.

Stramonium (*Botany*). The dried leaves and seeds of *Datura stramonium* (order, *Solanaceæ*) are used in the preparation of the drug.

Strand. (1) A number of single threads of some material (yarn, etc.) twisted together and forming one of the principal parts of a rope. (2) A single thready filament or small cord.

Stranded Conductor (*Elect. Eng.*) A conductor formed of a number of fine wires grouped into strands; used when flexibility is required.

Strap (*Eng.*) (1) A belt (*q.v.*) (2) A strip of metal specially shaped for holding together and strengthening parts of a structure round which it fits, *e.g.* an eccentric strap.

Strap Bar (*Eng.*) A bar sliding through fixed supports and carrying the STRAP FORK (*q.v.*)

Strap Brake (*Eng.*) A strip of metal, firmly fixed at one end, bent over a wheel or brake drum: when drawn tight by means of a lever, so as to grip the wheel closely, it acts as a brake. Used both as a brake proper and in certain forms of DYNAMOMETER (*q.v.*)

Strap End (*Eng.*) The end of a connecting rod in which the brasses are held in place by a strap passed round them and fixed to the rod by means of a gib and cottar (*q.v.*)

Strap Fork (*Eng.*) A two-pronged fork which loosely encloses a belt, for the purpose of shifting it from one pulley to another of equal size, turning on the same axis and placed alongside the first.

Strapping Motion (*Cotton Manufac.*) *See* GOVERNING MOTION.

Strap Work (*Architect.*) An Elizabethan ornament resembling interlacing straps.

Stratus Clouds (*Meteorol.*) Are those which present a stratified or band-like form. They may be high- or low-lying clouds. *See also* CLOUDS.

Strawberry (*Botany*). The fruit of *Fragaria vesca* (*Rosaceæ*) consists of a fleshy receptacle bearing numerous minute achenes (the so-called seeds).

Strawberry Leaf (*Her.*) An ornament of conventional form resembling a strawberry leaf appears on many ancient crowns and coronets. They now appear on the coronets of dukes, marquesses, and earls. *See* CORONET.

Stray Field (*Elect. Eng.*) A magnetic field, produced by lines of force from the field magnets of a dynamo which do not pass through the armature, and which are therefore useless for the purpose of inducing an electromotive force in the armature conductors.

Streak (*Min.*) The appearance produced when a piece of a mineral is rubbed over an abrading surface harder than its own. The lustre and general appearance of the streak is often a useful guide in the identification of a mineral.

Stream Currents (*Meteorol.*) Currents produced when DRIFT CURRENTS (*q.v.*) are deflected by a coast line or other obstacle.

Stream Lines. Imaginary lines drawn in a fluid in motion, such that the direction of motion of any particle at any given instant is a tangent to the curve passing through the particle.

Stream Tin (*Min.*) Tin-stone in a state of fine division which has been washed down and deposited by rivers.

Strength of Field (*Elect.*) The strength of an electric field at a point is measured by the number of lines of force per square centimetre at that point. In air this is numerically equal to the force in dynes exerted on a unit charge placed at the same point, but this will not be true for other media, the general relation between Force (dynes) and Field (lines per sq. cent.) being, Field = K × Force, where K is the dielectric constant (or specific inductive capacity), and is arbitrarily taken as unity for air. The strength of a magnetic field is similarly defined. In air this is numerically equal to force in dynes on unit pole at the given point, but the force is not to be confused with the field, the general relation being Field = μ × Force, where μ is the permeability of the medium. This practically only differs from unity in the case of iron and a few magnetic substances.

Strength of Pole. *See* MAGNET.

Strepitoso (*Music*). In an impetuous or boisterous manner.

Stress (*Phys., Eng., etc.*) A stress, from the practical point of view, is a force which produces, or tends to produce, an alteration in the form or dimensions of a body upon which it acts. The external force is resisted by internal forces acting between the molecules of the body, and to these internal forces the term "stress" is more properly applied. *See also* ELASTICITY.

Stress Diagram. A drawing made for the purpose of calculating the different stresses in the members of a loaded structure. *See also* GRAPHIC STATICS.

Stretched String (*Sound*). Vibrating strings form an essential part of many musical instruments (*q.v.*) and certain pieces of scientific apparatus, *e.g.* a SONOMETER (*q.v.*) The frequency of vibration of a string depend on its length, its mass, and the tension applied to it. Let l be the length, m the mass per unit length, and T the tension, expressed in the corresponding units of force (*i.e.* if l is in cms., m in grams, then T must be in dynes). The frequency n (or number of vibrations per second), when the string is vibrating as a whole and therefore emitting its fundamental note, is $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$. The frequencies of the over-tones (*q.v.*) will be $2n$, $3n$, etc.

Stretcher (*Build.*) (1) A brick or stone laid with the greatest length parallel to the surface of the wall. *Cf.* HEADER. (2) A tie-beam in the framing of a building.

—— (*Eng., etc.*) A strut or member of a structure which fixes two other parts a definite distance apart: *e.g.*, the horizontal member in an A-frame.

—— (*Paint.*) A frame on which a canvas intended for painting is fastened, and then stretched by means of wedges forced in at the corners, or by some other device.

Stretching Course (*Build.*) A row of bricks laid lengthwise on the face of a wall. *Cf.* STRETCHER.

Stretto (*Music*). Contracted; close. *See* FUGUE.

Striæ (*Glass Manufac.*) Markings or cords caused by variations in the temperature of the furnace. In flint glass they are chiefly due to the unequal density of the materials employed.

—— *or* **Striations** (*Elect.*) A banded appearance due to alternations of dark and bright spaces produced under certain conditions in vacuum tubes (*q.v.*)

Strickle (*Foundry*). A piece of wood or metal used to produce a surface of definite form on the sand in a moulding box. The strickle is cut to the required shape and drawn over the sand in the proper direction, which is maintained by means of suitable guides, pivots, etc.

Strickling (*Foundry*). Forming a simple mould or part of a mould by means of the STRICKLE (*q.v.*) instead of by the use of a pattern.

Strict Counterpoint (*Music*). By strict counterpoint is understood the art of combining melodies under the following restrictions: (1) Common chords and their first inversions only allowed. (2) A complete absence of discords, except the suspensions of the 4-3; 9-8; 7-6; 7-8; 5-6, and passing notes. (3) Diatonic progressions only. The study of strict counterpoint is perhaps the most essential part of a thorough musical training, as it enables the student to write in a flowing manner under very severe conditions. He is then fit to enter the much wider sphere of composition, which comprises writing and combining the five different species of counterpoint under modern conditions, using chromatic progressions, discords, and all the combinations and progressions of modern harmony. This is known as Free Counterpoint. These are also called respectively Students' Counterpoint and Composers' Counterpoint, terms which in many ways seem to be better. *See* COUNTERPOINT.

Strict Fugue (*Music*). A real FUGUE (*q.v.*)

Strigil (*Archæol.*) A scraper, fashioned variously, of metal, ivory, bone, etc., and used for scraping the skin at the bath or on other occasions.

Strike (*Build., etc.*) To lower or take down, *e.g.* a scaffold or the centre of an arch.

—— (*Geol.*) The direction of a horizontal line on the bedding plane of an inclined stratum. Otherwise: the compass bearing of the line formed by the intersection of the plane of an inclined stratum and a horizontal surface. It may best be realised by partly immersing a slate, inclined at any angle from the horizontal position, in a bowl of water; the line of contact of the water surface with the face of the slate is the direction of the strike. The definition of "strike" given in most text books is incorrect.

—— (*Typefounding*). The term applied to the matrix in which a type is cast. *See* TYPEFOUNDING.

Striker (*Print.*) A lever for shifting the driving belt of a machine to stop or start it.

Striking an Arc (*Elect.*) Starting an electric arc by bringing the carbons into contact and immediately separating them.

Striking a Screw (*Eng., etc.*) Commencing the cutting of a screw-thread with a chaser (*q.v.*)

Striking Distance (*Elect.*) The distance between two conductors, across which a spark will pass with a given difference of potential.

Striking Knife (*Carp., etc.*) A knife or scriber used in striking out or marking timber ready for cutting to shape.

Striking Mechanism (*Elect. Eng.*) The mechanism, usually worked by the current, by which the striking of an arc (*q.v.*) is effected

Striking Out (*Carp., Eng., etc.*) Drawing a piece of work, especially drawing it full size in the workshop, or actually marking out lines, etc., on the material itself.

Striking Plate (*Carp. and Join.*) The plate fixed to the jamb of a door frame for the bolt of the lock to shoot into.

Striking Reed (*Music*). *See* REED.

Striking Up, *or* Striking (*Foundry*). STRICKLING (*q.v.*)

String (*Mech.*) In theoretical mechanics the term string is applied to an imaginary body which is capable of transmitting a force only in the direction of its own length, *i.e.* which is perfectly flexible.

—— (*Mining*). A thin vein of ore.

—— (*Phys.*) *See* STRETCHED STRING.

—— (*Woollen and Worsted Manufac.*) A length of 10 ft. The chain or warp is frequently defined in strings.

String Course (*Architect.*) A horizontal moulding or a coloured or projecting band on the face of a building.

Stringendo (*Music*). Hurrying the time with excitement.

String Quartet (*Music*). A composition for four stringed instruments, generally first and second violins, viola, and violoncello.

Strings (*Carp. and Join.*) The inclined boards supporting the ends of steps. *See* STAIRCASE.

Strip *or* Taper (*Foundry*). *See* TAPER.

Strippers *or* Workers (*Textile Manufac.*) *See* CARDING ENGINE.

Stripping (*Eng.*) Tearing or breaking off the thread of a screw or the teeth of gear wheels through improper usage.

—— (*Lace Manufac.*) A simple method of removing the unused cotton that remains upon the brass bobbins, when time is an object or the material not of sufficient value to pay the expense of "jacking off." *See* JACK OFF.

Stripping Film (*Photo.*) A sensitive gelatine film which is mounted on paper or other non-transparent support; after the film has been developed and fixed, it is removed or stripped from the support, for printing.

Stripping Plate (*Met.*) A bevel edged template fitted tangentially to the rolls of a mill to coincide with the grooves, thus clearing the bars from the bottom roll, and preventing them "collaring" or wrapping round the bottom roll. It is fitted at the back of the rolls in almost the same position as the foreplate (*q.v.*) at the front.

Stroboscope (*Phys.*) An instrument for observing a body which is executing rapid vibrations. The body is viewed through a small opening in an opaque screen which is moving in the same plane as itself; if the rate of motion of the screen be the same as that of the vibrating body, the latter will appear at rest when viewed through the opening. For example, the screen may be mounted on the tip of the prong of a tuning fork; then if it be set in vibration, and another fork, vibrating in the same plane, with the same frequency, be observed through the slit, the prongs of the second fork will appear at rest; if the frequencies of the forks differ by a small amount, then the prong of the second fork will appear to move slowly to and fro.

Stroke (*Eng.*) The distance moved through by the piston of an engine, plunger of a pump, or other reciprocating mechanism.

Stroker (*Print.*) A piece of wood with a smooth metal face, used for stroking the sheets of paper towards the grippers of the printing machine.

Strong Sand (*Foundry*). Moulding sand rendered adhesive by the admixture of loam, etc.

Strontia (*Chem.*) Strontium oxide or hydroxide.

Strontianite (*Min.*) Strontium carbonate, $SrCO_3$; strontia = 70·2, carbon dioxide = 29·8 per cent. Orthorhombic, usually in divergently fibrous masses. Pale apple green, greyish or white. The principal source of strontium compounds. From Strontian in Argyleshire, Yorkshire, the Harz, New York State, etc.

Strontium (*Min.*) The element does not occur native. Only two minerals containing it are at all abundant, the carbonate Strontianite (*q.v.*) and the sulphate Celestine (*q.v.*)

Strontium and its Compounds (*Chem.*) STRONTIUM (Sr, atomic weight 87·6) belongs to the same group of elements as calcium and barium; like them it is a white metal, which decomposes water at the ordinary temperature, forming the hydroxide and liberating hydrogen; like them, also, it occurs as carbonate (Strontianite) and sulphate (Celestine); it is obtained pure in the same way as barium. COMPOUNDS: STRONTIUM OXIDE, SrO, resembles quicklime in appearance; melts about 3000°; more soluble in water than quicklime, giving a strongly alkaline solution of strontium hydroxide, $Sr(OH)_2$. The oxide is obtained by heating the nitrate or by very strongly heating the carbonate; the hydroxide is obtained by adding water to the oxide or by heating the carbonate in a current of steam. The HYDROXIDE is a white solid which crystallises from hot water, as $Sr(OH)_2 8H_2O$; it combines with cane sugar to form a saccharate, which is insoluble in water, and on this account strontium hydroxide is used in recovering cane sugar (*q.v.*) from the uncrystallisable molasses. STRONTIUM CHLORIDE, $SrCl_2$, crystallises with six molecules of water, and is soluble in water and alcohol; the anhydrous salt melts at 832°; it is obtained by dissolving the carbonate or hydroxide in hydrochloric acid and crystallising. STRONTIUM NITRATE, $Sr(NO_3)_2$, crystallises in anhydrous octahedra; very soluble in water; obtained by dissolving the carbonate in dilute nitric acid and evaporating. It is much used in making red fire. The carbonate and sulphate resemble the corresponding barium salts, but the sulphate is more soluble in water (·0145 gram $SrSO_4$ in 100 cc. water at 20°; ·00025 gram $BaSO_4$ in 100 cc. at 18°).

Struck Core (*Foundry*). *See* CORE.

Structure (*Eng.*, *etc.*) An assemblage of related parts attached to one another in a definite manner. In practice the term is usually, though not always, restricted to buildings, bridges, roofs, etc., as distinguished from machines.

Strut (*Build.*, *Eng.*, *etc.*) A member of a structure which is in compression, *i.e.* the forces applied at the two ends act towards each other.

Strychnine (*Botany*). The alkaloid obtained from the disclike seeds (Nux Vomica) of *Strychnos nux vomica* (order, *Loganiaceæ*).

—— (*Chem.*) $C_{21}H_{22}N_2O_2$. Forms large white rhombic prisms; melts about 266°; distils at 270° under a pressure of 5 mm.; slightly soluble in water (100 parts water dissolve ·025 parts at 14·5°), more soluble in alcohol (100 parts absolute dissolve ·302 at 8·25°): chloroform is the best solvent (1 part in 6·9); its solutions are lævorotatory. It has an extremely bitter taste—1 part in 70,000 of water is distinctly perceptible. Strychnine is intensely poisonous. The fatal dose is not known; a little over a grain has proved fatal, while larger doses have not. Medicinal dose, $\frac{1}{30}$ to $\frac{1}{16}$ grain; it is used in making many vermin killers, in which it is mixed with starch and a colouring matter such as ultramarine. In medicine it is used as a tonic on account of its stimulating action on various centres. In poisonous doses it causes violent and frequent convulsions, affecting nearly all the muscles; apomorphine and chloral are used as antidotes. Strychnine is a strong monacid base; its commoner salts are the sulphate, hydrochloride, nitrate, and acetate, all of which are more soluble in water than the alkaloid. In pure chemistry strychnine is used to resolve racemic mixtures or compounds into their optically active components. *See* STEREOISOMERISM *and* DEXTROSE. It occurs in nux vomica (dried ripe seeds) to the extent of from 0·9 to 1·9 per cent., and in St. Ignatius bean to 1·5 per cent.; brucine occurs with it in these. To obtain it the nuts are softened by exposure to steam, powdered, and extracted with somewhat diluted alcohol containing a little sulphuric acid; the filtered extract is neutralised with lime, and the clear solution evaporated; the residue is extracted with dilute acid, the extract filtered and precipitated with ammonia; the precipitate contains brucine, from which it can be freed by crystallisation from alcohol, in which brucine is the more soluble; or the alkaloids are dissolved in acetic acid, the solution evaporated on the water bath, when the strychnine acetate is decomposed, and water only dissolves brucine acetate from the residue. The constitution of strychnine is unknown; but it is a tertiary base, as it unites with alkyl iodides, and it appears to contain a benzene ring condensed with a nitrogen ring, the nature of which is not settled, for it yields halogen substitution products, of which bromstrychnine yields picric acid by the action of fuming nitric acid; also when distilled with caustic potash, quinoline and indole are among the products, while when distilled with zinc dust, carbazole is obtained. Strychnine gives the usual alkaloid reactions; the best test for it is the addition of strong sulphuric acid and a little dichromate of potash, when a transient violet coloration is observed.

Stuart's Granolith. *See* ARTIFICIAL STONE.

Stub Tenon (*Carp. and Join.*) A short tenon which does not pass right through the piece which contains the mortice.

Stucco (*Build.*) (1) Plaster of fine quality made from powdered white marble, gypsum, sand, and water: used to form the surface of walls and for ornament in relief. (2) Generally any plaster or cement used to form the external surface of a building, often finished off to imitate masonry.

Stück (*Music*). The German term for piece, as *Concertstück*, a concert piece.

Stuck Moulding (*Carp. and Join.*) Moulding which is worked on the solid wood, as distinguished from moulding which is formed on a separate piece of wood and afterwards attached to the main part of the work.

Stud (*Build.*) A post or upright support. One of the scantlings to which the match boards are nailed in a frame building.

Stud (*Eng.*) (1) A short projecting pin or boss. (2) A screw, having no fixed head, which is screwed into a tapped hole in some larger object, the nut being screwed on to the projecting end. (3) The transverse piece of cast iron in the link of a cable chain for the purpose of keeping the sides apart.

—— (*Watches and Clocks*). The fixed piece to which the outer end of a balance spring is attached. Any fixed piece forming a centre of motion for movable pieces, *e.g.* the various studs on which the different parts of the striking mechanism of a clock turn. *See also* STOP WATCH.

Stud Block (*Eng.*) A piece of metal having a tapped hole which does not pass right through the block. It is used for screwing studs (*q.v.*) into their holes.

Studded Chain (*Eng.*) A chain with STAYED LINKS (*q.v.*)

Studio (*Art*). The workroom of an artist; an atelier.

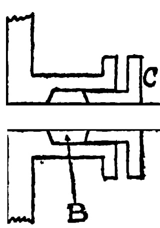
Stud Wheel (*Eng.*) A wheel revolving on a short fixed axle projecting from the framework of a machine; especially applied to a wheel used in screw-cutting lathes to connect the wheel on the mandrel with that on the leading screw.

Stuff. (1) A general term for material. (2) Woven material, especially a woollen fabric. (3) In joinery the term is applied to wood.

Stuff Chest (*Paper Manufac.*) A cylindrical tank, containing the stock of beaten pulp ready for moulding in the machine.

Stuffing (*Leather Manufac.*) Impregnating leather with grease. The two terms "stuffing" and "currying" differ only in degree, stuffing meaning a heavy currying. The term "currying" is used when only a light oiling is applied. *See* CURRYING.

Stuffing Box (*Eng.*) The device by which a steam-tight joint is obtained where a piston rod enters a cylinder. The rod A passes through a hole in the cylinder cover, which fits the rod smoothly; this hole widens out into a cylindrical chamber B of larger diameter than the rod, and soft packing of asbestos, etc., is placed in it so as to surround the rod. The end of the recess is filled by a short tube or sleeve C, termed a GLAND; this fits into the recess, and is bored out to such a size that the piston rod can move easily through it. The gland is held in place by bolts, and compresses the packing so as to fill the cavity round the rod, thereby making a steam-tight joint in which friction is reduced to a minimum.



STUFFING BOX.

Style (*Archæol., etc.*) (1) An instrument of bone, metal, or ivory, with one end pointed and the other end blunt, the pointed end being employed for inscribing on wax-covered tablets, and the other end for erasing and for smoothing the surface of the wax. (2) A pointed tool used in engraving, etc. (3) The marking point of a telegraph receiver, etc.

Style of the House (*Typog.*) A code framed for the guidance of compositors and others respecting punctuation, capitalisation, divisions, spacing, etc.

Styles (*Carp. and Join.*) The outside vertical members of a piece of framed work, such as a door.

Stylobate (*Architect.*) The substructure supporting a colonnade. It can be either in the form of a

STYLOBATE, TEMPLE OF CERES, PÆSTUM.

podium (*q.v.*) or a series of steps. The stylobate of the Parthenon consists of three steps.

Styrolene (*Chem.*) $\begin{array}{l}CHC_6H_5\\ \|\\ CH_2\end{array}$ (*also called* PHENYL-ETHYLENE STYRENE). A colourless liquid; boils at 144°; aromatic smell; soluble in alcohol and ether; polymerises on keeping, especially in light; it occurs in the balsam Storax (1 to 5 per cent.) and in coal tar. It can be obtained by distilling storax with water; by decomposing β-bromhydrocinnamic acid (from cinnamic acid and hydrobromic acid) with caustic soda—

$$\begin{array}{l}CHBr\,.\,C_6H_5\\ |\\ CH_2\,.\,COOH\end{array} = \begin{array}{l}CHC_6H_5\\ \|\\ CH_2\end{array} + HBr + CO_2$$

or by condensing benzene and acetylene with aluminium chloride.

Suabe Flute (*Music*). An organ stop of wood, having an inverted mouth. Its tone is of a somewhat sorrowful character. It seldom goes below tenor C, but is grooved into a stopped diapason.

Suave (*Music*). Agreeable; sweet.

Subaerial Denudation (*Geol.*) *See* DENUDATION.

Sub-bass (*Music*). A pedal stop on organs of 32 ft. tone. The term is, however, sometimes used in the same sense as, or instead of, bourdon, and then is of 16 ft. tone.

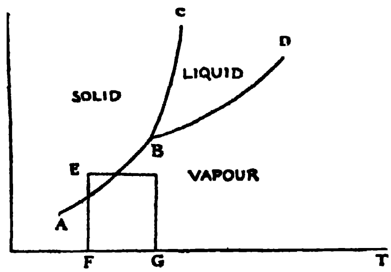
Subdominant (*Music*). The *Under-dominant.* The technical name of the fourth note of a scale, so called from its being in the same position below the tonic as the dominant is above.

Subito (*Music*). Suddenly; quickly.

Subject (*Music*). (1) The principal phrase, or sets of phrases, constituting the complete theme of a movement. (2) The opening phrase of a fugue. *Cf.* ANSWER.

Sublimation (*Chem.*) Strictly speaking, is the change of a solid to a gas without previous melting, and the change of the gas back to the solid without liquefaction. But the term is often applied to a substance which melts on heating, and then boils and gives off a gas which condenses to a solid without liquefaction. Any substance will come under the strict definition which has a sufficient vapour pressure at a temperature below its melting point. Thus camphor melts at 180°, but it sublimes at the ordinary temperature; this is due to the fact that camphor has a considerable vapour pressure at, say, 15°, so that if a piece of camphor is placed under a bell jar at this temperature, the space is filled with vapour of camphor, and part of it condenses again on the colder sides of the jar. Again, when sulphur is purified by distilling it in iron vessels and passing

the vapour into a large brick chamber, the vapour solidifies at first without liquefying; this is not a strict sublimation, and the sulphur solidifies in this case because of the lowering of its temperature by expansion against the pressure of the air and the lowering of its vapour pressure owing to the vapour mixing with air. In the diagram let the horizontal line represent temperatures, the vertical line pressures, the curve AB the vapour pressure of the solid, the curve BD the vapour pressure of the liquid, and the curve BC the effect of pressure on the melting point;



then it is seen that at any pressure below that at the triple point B a solid can pass into the state of vapour without liquefaction, and vapour to solid without liquefaction. Select a pressure FE, and heat the solid in a vessel at temperature G, and let the vessel communicate with another at temperature F; then the solid will sublime without melting. Ice melts at 0° very nearly, and the value of B is about 4·6 mm; so that if ice is placed in a vessel the pressure inside which is kept, say, at 3 mm. and the temperature 0°, the ice would slowly sublime, and might be condensed in a second vessel at the same pressure as the first, but at a lower temperature. Many substances are purified by subliming them, as, for example, iodine, arsenious oxide, benzoic acid, ammonium chloride.

Submarine Cable (*Elect.*) A conductor or system of conductors electrically insulated and provided with a strong covering, proof against the action of sea water. Used chiefly for telegraphic communication.

Submediant (*Music*). The *Under-mediant.* The technical name of the sixth note of a scale; so called from its being in the same position, *i.e.* midway, between tonic and the subdominant in descending, as the mediant is between tonic and dominant in ascending.

Sub-octave (*Music*). A coupler in an organ which causes the note an octave below the note played to fall.

Substitution (*Chem.*) The replacement of one or more atoms in the molecule of a compound by one or more different atoms or groups of atoms, the valency of which is equal to that of the atom or atoms replaced. The product of such a change is called a substitution product. As an example of substitution may be given the action of chlorine on acetic acid:

$\begin{array}{l}CH_3\\ \mid\\ COOH\end{array}$	$\begin{array}{l}CH_2Cl\\ \mid\\ COOH\end{array}$	$\begin{array}{l}CHCl_2\\ \mid\\ COOH\end{array}$	$\begin{array}{l}CCl_3\\ \mid\\ COOH\end{array}$
Acetic Acid.	Monochloracetic Acid.	Dichloracetic Acid.	Trichloracetic Acid.

A great part of the reactions of organic chemistry are substitution reactions, and organic chemistry has been defined as the chemistry of the hydrocarbons and their derivatives, that is, their substitution products. The substituent, as the entering group is called, always changes the properties of the original compound; thus in the example above the strength of the acid increases with the number of chlorine atoms. In some classes of compounds rules are known relating to the place where a substituent will enter; thus in the fatty acids halogens enter the group next to the carboxyl group. In benzene, if a hydrogen atom is substituted by one of the following, Cl, Br, I, CH_3, and other alkyls, CH_2Cl, CH_2CN, CH_2COOH, OH, OCH_3, NH_2, $NHCOCH_3$, $-N=N-$, C_6H_5, a new substituent enters the ortho- or para-position, and little or no meta-derivative is formed; but if a hydrogen is substituted by one of the following, NO_2, SO_2OH, CHO, COOH, $COCH_3$, CN, a new substituent will enter the meta-position, and little or no ortho- and para-derivative will be formed.

Subtonic (*Music*). The Leading Note (*q.v.*)

Succentor (*Music*). The deputy of the Precentor (*q.v.*)

Succinic Acid (*Chem.*)

$$\begin{array}{l}CH_2COOH\end{array}$$

White monoclinic prisms; melts at 185°; boils at 235°, with decomposition into anhydride,

$$\left.\begin{array}{l}CH_2.CO\\ \mid\\ CH_2.CO\end{array}\right\rangle O,$$

and water; soluble in water and alcohol; sparingly soluble in ether. It occurs in amber, many resins, in turpentine, in the oxidation of fats with nitric acid, in the alcoholic fermentation of sugar, and in urine. It can be prepared by the distillation of amber; by fermentation of ammonium tartrate in presence of small quantities of potassium phosphate, magnesium sulphate, and calcium carbonate to serve as food for the ferment. The fermentation starts on exposure to air, and with 2,000 grs. of tartaric acid it is complete in about seven weeks at 25° to 30°. The liquid is concentrated, cleared by albumen, precipitated with lime, and the calcium succinate decomposed by sulphuric acid; it is also formed by fermentation of calcium malate. Synthetically it can be obtained in many ways, *e.g.* from malonic acid (*q.v.*), and in a similar way from ethyl acetoacetate (*q.v.*); from ethylene by the following reactions:

$$\begin{array}{l}CH_2\\ \Vert\\ CH_2\end{array} \xrightarrow{Br} \begin{array}{l}CH_2Br\\ \mid\\ CH_2Br\end{array} \xrightarrow{KCN} \begin{array}{l}CH_2CN\\ \mid\\ CH_2CN\end{array} \xrightarrow{H_2O} \begin{array}{l}CH_2COOH\\ \mid\\ CH_2COOH\end{array}$$

With phosphorus pentachloride it gives either the anhydride or succinyl chloride:

$$\left.\begin{array}{l}CH_2.CCl_2\\ \mid\\ CH_2.CO\end{array}\right\rangle O$$

Its sodium salt on distillation yields *p*-diketohexamethylene:

$$\begin{array}{l}CH_2COONa\\ \mid\\ CH_2COONa\end{array} + \begin{array}{l}NaOOC.CH_2\\ \qquad\quad\mid\\ NaOOC.CH_2\end{array} = 2Na_2CO_3 + \begin{array}{l}CH_2-CO-CH_2\\ \mid\qquad\qquad\quad\mid\\ CH_2-CO-CH_2\end{array}$$

When heated with phosphorus trisulphide it yields thiophene (*q.v.*) *See also* Resorcin.

Succinimide (*Chem.*) *See* Pyrrole.

Suction (*Eng., etc.*) The drawing of fluid into a vacuum produced by the movement of a piston or plunger in a pump barrel.

Suction Pump. *See* Pumps.

Suffolks. *See* Bricks.

Sugar Cane. Cane sugar is prepared from the juice of the stem of a tall, strong perennial grass, *Saccharum officinarum* (order, *Gramineæ*), growing in tropical and subtropical regions. Molasses, treacle, and rum are derived from the sugar cane.

Sugar made from Rags, etc. (*Chem.*) *See* CELLULOSE.

Sugars (*Chem.*) Compounds: (1) of the formula $R - (CHOH)_n - CHO$, where R is hydrogen or occasionally CH_3 and $n = 1, 2, 3, \ldots$ etc.; (2) of the formula $R - (CHOH)_n - CO - CH_2OH$, where R and n have the same meaning as in (1); (3) derived from (1) and (2) by anhydride formation between a member from each or between two members from (1) or between two members of (1) and one member of (2). Members of Class (1) are called aldoses because they are all aldehydes; members of Class (2) are called ketoses because they are all ketones. Members of each class are distinguished by the number of carbon atoms they contain (not counting R), and it will be seen that the simplest member of Class (1) contains two carbon atoms—

$$\begin{array}{c} CH_2OH \\ | \\ CHO \end{array}$$

It is a biose; the simplest member of Class (2) contains three carbon atoms—

$$\begin{array}{c} CH_2OH \\ | \\ CO \\ | \\ CH_2OH \end{array}$$

It is a triose, and to distinguish it from the triose of Class (1)—

$$\begin{array}{c} CH_2OH \\ | \\ CHOH \\ | \\ CHO \end{array}$$

the former is a ketotriose and the latter is an aldotriose. A mixture of these two trioses is obtained by the cautious oxidation of glycerine (*q.v.*), and has been called glycerose, and glycerose has been used in the synthesis of sugars. *See* DEXTROSE. The six carbon atom sugars are called hexoses, also saccharoses; members of Class (3), derived from two saccharoses, are called disaccharoses, etc. (sometimes disaccharides). Most of the sugars are known by names given to them before any systematic way of naming them was in use, and these names are retained; also the above names serve only as class names, and would not serve to distinguish between stereoisomers, which are very numerous in the sugars. Examples of sugars are: Biose (glycollic aldehyde),

$$\begin{array}{c} CH_2OH \\ | \\ CHO \end{array}$$

trioses, glycerose; tetroses, erythrose (*see under* ERYTHRITOL); tetroses, arabinose (*q.v.*); methylpentose, rhamnose (*q.v.*); hexoses, dextrose (*q.v.*), lævulose (*q.v.*), galactose (*q.v.*); disaccharoses, cane sugar (*q.v.*), maltose (*q.v.*), lactose (*q.v.*); trisaccharoses, raffinose (*q.v.*) For the properties of a typical aldose, *see* DEXTROSE; of a typical ketose, *see* LÆVULOSE. *See also* OSAZONES *and* OXIMES.

Suint. The natural grease impregnating freshly cut sheep's wool. It is the raw material from which lanoline (*q.v.*) is prepared.

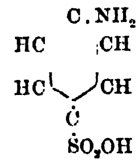
Suite. (1) A series of apartments connected together. (2) A number of pictures illustrating consecutive events.

—— (*Music*). A set of dance tunes in one key. The precursor of the SONATA (*q.v.*)

Suivez (*Music.*) A term warning an accompanist to be extra watchful.

Sullage (*Met.*) Dross, scoriæ, etc., which collect on the surface of fluid metal.

Sulphanilic Acid (*Chem.*)



Crystallises in rhombic plates containing one molecule of water; sparingly soluble in cold water, more soluble on boiling; the crystals effloresce; fused with caustic potash, it gives aniline; bromine water converts it into tribromaniline; on oxidation with manganese dioxide and sulphuric acid it gives quinones; it is easily diazotised. To prepare it aniline (100 parts) and sulphuric acid (105 parts) are heated at 180° to 220°, till all the aniline is changed. Sulphanilic acid is largely used in the preparation of dyes, *e.g.* methyl orange.

Sulphate of Baryta (*Min.*) A synonym for Barytes (*q.v.*)

Sulphate of Iron (*Min.*) *See* COPPERAS.

Sulphate of Lead (*Min.*) *See* ANGLESITE.

Sulphate of Lime (*Min.*) *See* GYPSUM.

Sulphate of Strontia (*Min.*) *See* CELESTINE.

Sulphates (*Chem.*) Salts derived from sulphuric acid. The more important sulphates are described under the respective metals, *q.v.*

Sulphating (*Elect. Eng.*) A defect due to the formation of lead sulphate on the plates of a secondary or storage cell.

Sulphides (*Chem.*) Compounds formed by the union of sulphur with another element or group of elements acting as a single element. The metallic sulphides may be regarded as salts of sulphuretted hydrogen. The more important sulphides are described under the respective metals, etc.

Sulphites (*Chem.*) Salts derived from sulphurous acid. The more important sulphites are described under the respective metals, etc.

Sulphite Wood Pulp (*Paper Manufac.*) Pulp prepared from wood by treatment with bisulphite of lime under pressure. *See* WOOD PULP.

Sulphocyanates (*Chem.*) (*also called* **Sulphocyanides**). Salts of the unstable sulphocyanic acid, HCNS. The most important sulphocyanates are those of potassium, ammonium, mercury, and silver. Ammonium sulphocyanate closely resembles the potassium salt (*see* POTASSIUM COMPOUNDS); it is obtained by warming a mixture of alcohol, ammonia, and carbon disulphide; like the cyanate, it undergoes rearrangement on heating—forms sulphourea. *See* GUANIDINE. The mercuric salt, $Hg(CNS)_2$, is formed by double decomposition; it is the substance used in making Pharaoh's serpents. The silver salt, AgCNS, is also made by double decomposition, and is

insoluble in nitric acids. Ferric sulphocyanate gives a blood red coloration in water, and its formation is used as a delicate test for ferric salts.

Sulphonal (*Chem.*) $(CH_3)_2C(SO_2C_2H_5)_2$ (Diethyl sulphone dimethylmethane). Thick, colourless prisms; melts at 126°; boils about 300°; sparingly soluble in cold water, much more soluble in hot water; sparingly soluble in alcohol; soluble in chloroform. It is a good hypnotic, and is used in medicine. It is a very stable substance; heated with potassium cyanide or charcoal it gives a smell of mercaptan; fused with caustic potash it gives a smell of mustard oil. It is prepared by treating sodium ethyl thiosulphate (from aqueous solution of sodium thiosulphate by heating with ethyl bromide) with acetone and hydrochloric acid, when acetone mercaptol is obtained. The thiosulphate and hydrochloric acid give mercaptan,

$$(CH_3)_2CO + 2HS.C_2H_5 = (CH_3)_2C(SC_2H_5)_2 + H_2O.$$

The acetone mercaptol on oxidation with potassium permanganate gives sulphonal. Also obtained by condensing aldehyde and mercaptan with hydrochloric acid, oxidising the product with potassium permanganate, and dissolving the ethylidene diethylsulphone with methyl iodide in benzene, and adding sodium:

$$CH_3CHO \xrightarrow[HSC_2H_5]{} CH_3CH\Big\langle{}^{SC_2H_5}_{SC_2H_5} \xrightarrow[O]{}$$

Ethylidene Mercaptol, B.P. 186°

$$CH_3CH\Big\langle{}^{SO_2C_2H_5}_{SO_2C_2H_5} \xrightarrow[CH_3I + Na]{} (CH_3)_2C(SO_2C_2H_5)_2$$

Ethylidene Diethylsulphone, M.P. 75°.

Sulphonation (*Chem.*) The operation of making sulphonic acids.

Sulphonic Acids (*Chem.*) Acids of the formula $R.SO_2.OH$. They are strong acids isomeric with the corresponding sulphites. The alkaline sulphites, however, have most probably the sulphonic constitution. Examples of inorganic sulphonic acids are chlorosulphonic acid, $SO_2\Big\langle{}^{Cl}_{OH}$, from sulphuric acid by the action of phosphorus pentachloride, and hydroxylamine disulphonic acid (salts only known), obtained by passing sulphur dioxide in a solution in molecular proportions of potassium nitrate and bicarbonate—

$$HO.NO + 2H.SO_2OH = HO.N(SO_2OH)_2 + H_2O$$

The sulphonic acids of the fatty series are not very important; they may be obtained by oxidising mercaptans (*q.v.*) with nitric acid. Taurine (*q.v.*) is a fatty sulphonic acid of physiological interest. The aromatic sulphonic acids are of great technical importance; unlike the fatty acids, they can be obtained by the direct action of sulphuric acid on aromatic compounds. All sulphonic acids yield chlorides when their alkali salts are treated with phosphorus chlorides, and the sulphonic chlorides easily yield sulphonamides when treated with ammonium carbonate—

$$R.SO_3K \xrightarrow[PCl_5]{} RSO_2Cl \xrightarrow[NH_4HCO_3]{} RSO_2NH_2$$

For examples of sulphonic acids, *see* BENZENE SULPHONIC ACID; the various NAPHTHALENE DERIVATIVES; SACCHARIN; SULPHANILIC ACID.

Sulphur (*Chem.*) S. Atomic weight, 32·06. A yellow solid element which belongs to the same chemical family as oxygen, Group VI. of the Periodic System. It is capable of existing in many different forms: α- or rhombic form: this occurs naturally, and is obtained in octahedral crystals, when any solution of sulphur in carbon disulphide is allowed to evaporate at the ordinary temperature; it melts at 114·5°. This form can exist in various crystalline modifications. β- or monoclinic sulphur is obtained in monoclinic prisms by melting sulphur, allowing it to cool till a crust forms, piercing the crust in several places, and pouring out the still liquid sulphur; it melts at 119·25°, is soluble in carbon disulphide, and exists in at least three crystalline modifications. The transition point for α- and β-sulphur is 95·5°; but if α-sulphur is heated somewhat above this temperature it will not pass into the β-form, owing to phase inertia. On touching it with a crystal of β-sulphur it will change at once; similarly β-sulphur can persist for a while, but ultimately passes into the α-form at the ordinary temperature. When benzene is saturated with sulphur at its boiling point, the solution will deposit the β-form above 75°, then a mixture of β- and α-forms till 22°, below which α-sulphur crystallises out. The change of β to α is accompanied by evolution of heat. When sulphur near its boiling point is poured into cold water, plastic sulphur is obtained, an elastic solid becoming brittle on standing, and insoluble in carbon disulphide. MILK OF SULPHUR, which is used in medicine, is amorphous and soluble in carbon disulphide; it is obtained by boiling flowers of sulphur (2 parts) with quicklime (1 part) which has been slaked with 3 parts of water, and 13 parts of water, and precipitating the solution with hydrochloric acid. When sulphur is heated above its melting point, it changes from a pale yellow liquid to a red liquid at 156°, increases in viscosity to a maximum at 180°, and then diminishes in viscosity to its boiling point at 444·5°. Its vapour density just above its boiling point indicates a complex molecule, probably S_8, but about 1,000° its vapour density corresponds to that of a diatomic molecule, S_2. Its molecular weight, determined by the lowering of the freezing point (in naphthalene) and by the raising of the boiling point (in carbon disulphide), corresponds to S_8. Sulphur combines directly with most of the other elements on heating, and with some at the ordinary temperature. In air it slowly combines with the oxygen at the ordinary temperature, forming the dioxide; in oxygen it unites at about 275° or in air at 360°, and burns with a blue flame; the principal product being the dioxide, only a trace of the trioxide is formed. It combines with mercury and silver at the ordinary temperature. Sulphur occurs uncombined in all volcanic regions. In combination it occurs as sulphides, such as iron pyrites, FeS_2, copper pyrites, $CuFeS_2$, galena, PbS, zinc blende, ZnS, cinnabar, HgS, stibnite, Sb_2S_3, orpiment, As_2S_3, realgar, As_2S_2; as sulphates, such as gypsum, $CaSO_4 2H_2O$ (*see also* ALABASTER *and* SELENITE), heavy spar, $BaSO_4$, celestine, $SrSO_4$, kieserite, $MgSO_4H_2O$; it also occurs in combination in hair, proteids, mustard oils, bile acids, and as sulphuretted hydrogen in many mineral springs. Most sulphur is obtained in Sicily; the crude sulphur is built up in stacks on a sloping floor, the stack being covered with spent stuff from a previous operation; air openings are provided in the stack and cover, and the sulphur is ignited, when it melts and flows out at the lowest part of the floor into troughs. It is purified by distillation in an iron retort, and condensation in a large brick chamber; the first portions are solid and form the flowers of sulphur of com-

merce; but when the chamber gets hot the sulphur melts, and this part is cast, forming ordinary stick sulphur. A certain amount of sulphur is obtained from alkali waste by Chance's process (*q.v.*)

Sulphur (*Min.*) Native sulphur; orthorhombic, also massive and in incrustation; yellow to reddish. It is one of the group of minerals often associated with Gypsum. Rarely found in metalliferous veins, as at Dufton mines in Westmorland. Considerable deposits occur in volcanic regions, as in Sicily, near Naples, in Iceland, Java, etc. Also from Spain, Chile, California, Hawaii, etc.

Sulphur Compounds (*Chem.*) HYDROGEN SULPHIDE, H_2S (Sulphuretted hydrogen). Is a colourless gas; melts at $-86°$; boils at $-62°$; soluble in water (1 vol. of water dissolves 3·23 vols. of the gas at 15°). It has a fœtid smell and is very poisonous (0·05 per cent. in air produces marked symptoms of poisoning in a few minutes). On heating, the gas begins to decompose into its elements at 400°. It burns easily in air or oxygen—to sulphur dioxide and water when the supply of oxygen is sufficient; to sulphur and water otherwise. The halogens decompose it, chlorine, for example, giving sulphur and hydrochloric acid, or if the halogen is in excess, sulphur chloride and hydrochloric acid. Many metals decompose it: thus silver is blackened by it, being changed to sulphide, and tin, when heated in the gas, also decomposes it. Hydrogen sulphide is a reducing agent, as the following examples show:

$$2FeCl_3 + H_2S = 2FeCl_2 + 2HCl + S$$
$$2KMnO_4 + 4H_2SO_4 + 5H_2S = 2KHSO_4 + 2MnSO_4 + 8H_2O + 5S$$
$$2H_2S + SO_2 = 2H_2O + 3S$$

A solution of the gas in water behaves as a feeble acid; when the gas is passed into solutions of alkalis it forms salts: $2KOH + H_2S = K_2S + 2H_2O$ and $KOH + H_2S = KSH + H_2O$. On passing the gas into a solution of a salt of a metal which forms a sulphide insoluble in water, that sulphide is precipitated, completely if the sulphide is insoluble in the dilute acid liberated, incompletely if the sulphide is soluble in the dilute acid liberated, *e.g.*

$$HgCl_2 + H_2S = \underset{\substack{\text{Insoluble.}\\ \text{Precipitation complete.}}}{HgS} + 2HCl$$

$$ZnSO_4 + H_2S = \underset{\substack{\text{Soluble.}\\ \text{Precipitation incomplete.}}}{ZnS} + H_2SO_4$$

Hence the use of hydrogen sulphide as a reagent in qualitative analysis (*q.v.*) Sulphuretted hydrogen occurs as a product of the putrefaction of proteid; it also occurs in many mineral waters, such as those of Strathpeffer and Harrogate. It is obtained by passing hydrogen into boiling sulphur or for ordinary laboratory purposes by the action of dilute hydrochloric or sulphuric acids on ferrous sulphide. When required pure, black antimony sulphide is heated with concentrated hydrochloric acid. The gas is easily recognised by its turning strips of filter paper which have been dipped in lead acetate solution black, or by its smell. *Halogen Compounds:* The HEXAFLUORIDE, SF_6, is a colourless, odourless, and very stable gas; it is obtained by the direct action of fluorine on sulphur, when the sulphur burns and forms a mixture of fluorides. The mixture is liquefied at $-80°$, fractionally distilled, treated with concentrated caustic potash, and dried over solid potash. SULPHUR MONOCHLORIDE, S_2Cl_2, is a reddish yellow liquid; boils at 138°; has unpleasant smell; readily dissolves sulphur, and is on this account used in vulcanising indiarubber; it is decomposed by water, but not in a simple way. Among the products are sulphur, sulphur dioxide, and hydrochloric acid; metals yield chlorides and sulphur. It is prepared by passing dry chlorine over gently heated sulphur, leaving some undissolved sulphur, and rectifying the product till it boils constantly at 138°. The remaining halogen compounds are unimportant. *Oxides:* SULPHUR DIOXIDE, SO_2 (Sulphurous anhydride), is a colourless gas; melts at $-76°$; boils at $-8°$; has a keen, choking smell; very soluble in water; at 0° 1 vol. water dissolves 79·79 vols. of the gas, and at 20°, 39·37 vols. It is a very heavy gas, being just over two and a quarter times as heavy as air. Sulphur dioxide is decomposed by strong sunlight to sulphur and sulphur trioxide, and electric sparks produce the same effect, but the decomposition is not complete. It unites directly with chlorine in sunlight to form sulphuryl chloride, $SO_2 + Cl_2 = SO_2Cl_2$. It unites with oxygen when the two gases, dried over sulphuric acid, are passing over heated platinum black, $SO_2 + O = SO_3$. A number of metals burn in it when heated, forming sulphides and oxides, and in the case of potassium, sulphite and thiosulphate; lead dioxide unites energetically with it to form lead sulphate. The solution of sulphur dioxide in water behaves as a weak dibasic acid—SULPHUROUS ACID, $SO_2 + H_2O = H_2SO_3$; its salts are called SULPHITES. Sulphurous acid unites with oxygen to form sulphuric acid, and is therefore a reducing agent, a disinfectant, and a bleaching agent. As examples of its reducing action may be given:

$$Fe_2(SO_4)_3 + H_2SO_3 + H_2O = 2FeSO_4 + 2H_2SO_4$$
$$\underset{\text{Orange.}}{2CrO_3} + 3H_2SO_3 = \underset{\text{Green.}}{Cr_2(SO_4)_3} + 3H_2O$$

As a disinfectant it is used in rooms which have been occupied by persons suffering from infectious diseases. As a preservative it is used in solution for painting over meat in warm weather. In bleaching it is used for material which would be injured by chlorine, such as blankets and straw. The gas may be prepared in a variety of ways, *e.g.* by burning sulphur in air or oxygen, by the action of most acids on sulphites, by heating copper, mercury, silver, or carbon with concentrated sulphuric acid when the latter is reduced to sulphurous acid. The gas is easily detected by its smell and its property of turning a strip of filter paper moistened with a solution of a chromate green. SULPHUR TRIOXIDE, SO_3 (Sulphuric anhydride), is a white solid crystallising in silky needles or in prisms; melts at 15°; combines with great energy with water to form sulphuric acid, and with basic oxides to form salts: thus barium oxide becomes red hot and forms the sulphate. It is prepared by direct union of the dioxide and oxygen in presence of heated, finely divided platinum. Both gases must be dry, and so, too, the apparatus; it may also be prepared by distilling fuming sulphuric acid. By the former of these methods it is prepared on a very large scale for the manufacture of concentrated sulphuric acid and fuming sulphuric acid. SULPHURIC ACID, H_2SO_4 (oil of vitriol), is a colourless oily liquid which fumes slightly in air; melts at 10·5°; sp. gr. at 15°, 1·838; boils, with decomposition into anhydride and water, and its boiling point attains a maximum at 338°. The ordinary pure concentrated acid of the laboratory contains about 95·6 per cent. H_2SO_4, and has a specific gravity of 1·84 at 15°. Acid of 97·7 per cent. has a specific gravity of 1·8415, and acid of 99·2 per cent. has again a specific gravity of 1·84. The acid of strength between the last two

appears to have some remarkable properties; thus it absorbs sulphur trioxide far better than at any other concentration; the maximum boiling point is possessed by an acid of 98·5 per cent.; further, acid over 97·7 per cent. has a peculiar action on cast iron, for when heated in cast iron vessels they do not appear to be attacked, but after a while they will suddenly break. Such acid can be heated in wrought iron vessels without these being attacked. Sulphuric acid unites with water to form several definite hydrates, *e.g.* $H_2SO_4H_2O$, which is a crystalline solid and melts at 8°, and $H_2SO_4 4H_2O$, which melts at −25°. On mixing the acid with water, much heat is given out; the mixture in gram molecular proportions evolves 6,336 calories, while every extra gram molecule of water added gives a less and less amount: thus, when 5 gram molecules of water have been added, the total heat evolved is 13,020 calories. On account of its affinity for water, sulphuric acid is often used as a drying agent: thus gases not acted on by it are bubbled through it to dry them, and substances are often dried by exposing them in a basin over strong sulphuric acid in a closed vessel (desiccator), which may or may not be exhausted of air. Also the acid will often take away the elements of water from a compound when allowed to stand with it, or on heating with it; *e.g.* blue copper sulphate becomes white, formic acid on heating gives carbon monoxide, oxalic acid gives both oxides of carbon, cane sugar gives charcoal and water. The more easily oxidisable metals are oxidised to sulphates when heated with the strong acid, while the part of the acid which has effected the oxidation is reduced to sulphurous acid. Many ring compounds are converted by heating with the strong acid into sulphonic acids (*q.v.*) When the strong acid is heated with salts of acids more volatile than sulphuric acid, a sulphate is formed, and the more volatile acid will escape if the reaction mixture is kept at a suitable temperature: the preparation of hydrochloric acid, nitric acid, and glacial acetic acid are illustrations of this statement. The diluted acid has the properties of a strong dibasic acid, dissolving many metals, with liberation of hydrogen and formation of a sulphate, and converting many basic oxides, hydroxides, carbonates, and sulphides to sulphates. The less concentrated acid is prepared by allowing a mixture of sulphur dioxide, air, higher oxides of nitrogen, and steam to react in leaden chambers at about 60°, when a complex series of reactions occurs, such as—

$$SO_2 + H_2O + NO_2 = H_2SO_4 + NO$$
$$NO + O = NO_2$$

$$2SO_2 + H_2O + NO_2 + NO + O_2 = 2SO_2\left\langle\begin{matrix}OH\\NO_2\end{matrix}\right.$$

$$2SO_2\left\langle\begin{matrix}OH\\NO_2\end{matrix}\right. + H_2O = 2SO_2\left\langle\begin{matrix}OH\\OH\end{matrix}\right. + NO_2 + NO$$

from which it is seen that the oxides of nitrogen act only as carriers of oxygen. The most concentrated acid and also fuming sulphuric acid are prepared by passing washed dust free and dried sulphur dioxide and excess of air over platinised asbestos, which is heated to about 425° to start the reaction, then cooled by the entering gases subsequently, as the reaction once started evolves heat. Ordinary concentrated sulphuric acid (95·6 per cent., H_2SO_4) can be converted into 100 per cent. acid by freezing or by adding the calculated quantity of sulphur trioxide. *See* SULPHURIC ACID MANUFACTURE. Sulphuric acid is used on an enormous scale in the manufacture of sodium carbonate; of other acids, such as nitric and hydrochloric and acetic; in oil refining, in indigo making, in the manufacture of many dyes. ACID CHLORIDES OF SULPHURIC ACID: (1) Chlorosulphonic acid, $SO_2\left\langle\begin{matrix}Cl\\OH\end{matrix}\right.$, is a colourless fuming liquid; boils at 152°. It is obtained by the direct union of sulphur trioxide and hydrogen chloride—

$$SO_3 + HCl = SO_2\left\langle\begin{matrix}Cl\\OH\end{matrix}\right.$$

and by the action of phosphorus pentachloride on sulphuric acid—

$$SO_2\left\langle\begin{matrix}OH\\OH\end{matrix}\right. + PCl_5 = SO_2\left\langle\begin{matrix}Cl\\OH\end{matrix}\right. + POCl_3 + HCl$$

(2) Sulphuryl chloride, $SO_2\left\langle\begin{matrix}Cl\\Cl\end{matrix}\right.$, is a colourless fuming liquid; boils at 69°. It is occasionally used as a chlorinating agent in organic chemistry. It is made by the direct action of chlorine on sulphur dioxide in sunlight, or by boiling chlorosulphonic acid with mercuric sulphate (1 per cent.: it acts as a catalytic agent). Both these chlorides of sulphuric acid are of interest as throwing light on the constitution of sulphuric acid, for besides the methods of formation which show their relation to sulphuric acid very clearly, they are both decomposed by water into hydrochloric and sulphuric acids—

$$SO_2\left\langle\begin{matrix}OH\\Cl\end{matrix}\right. + HOH = SO_2\left\langle\begin{matrix}OH\\OH\end{matrix}\right. + HCl$$

$$SO_2\left\langle\begin{matrix}Cl\\Cl\end{matrix}\right. + 2HOH = SO_2\left\langle\begin{matrix}OH\\OH\end{matrix}\right. + 2HCl$$

FUMING SULPHURIC ACID, $H_2S_2O_7$ (Nordhausen sulphuric acid; Disulphuric acid; Pyrosulphuric acid), is a colourless, oily, fuming liquid. It gives off sulphur trioxide on warming. Unites with great energy with water. It is used in the preparation of aromatic sulphonic acids. It forms a definite series of salts, of which the sodium salt is typical. This salt is obtained by carefully heating acid sodium sulphate—

$$\begin{matrix}SO_2\left\langle\begin{matrix}ONa\\OH\end{matrix}\right.\\SO_2\left\langle\begin{matrix}OH\\ONa\end{matrix}\right.\end{matrix} = \begin{matrix}SO_2\left\langle\begin{matrix}ONa\\ \end{matrix}\right.\\SO_2\left\langle\begin{matrix} \\ONa\end{matrix}\right.\end{matrix} + H_2O$$

The acid is prepared by passing sulphur trioxide into concentrated sulphuric acid, also by distilling partially roasted ferrous sulphate. As a manufacturing process the latter method has been replaced by the former. Ordinary fuming sulphuric acid is usually a mixture of disulphuric acid and ordinary sulphuric acid or sulphur trioxide, according to the strength of the fuming acid. PERSULPHURIC ACID,

$$H_2S_2O_8 = SO_2\left\langle\begin{matrix}OH\,HO\\O-O\end{matrix}\right\rangle SO_2$$

The pure substance is unknown. An aqueous solution is obtained by decomposing barium persulphate with dilute sulphuric acid. The anhydride is obtained by passing a silent electric discharge through a mixture of sulphur dioxide and oxygen, as an oil which crystallises at 0°, and has the formula S_2O_7; but when water acts upon this it decomposes in part

to sulphuric acid and oxygen. When strong sulphuric acid acts on a persulphate, persulphuric acid is liberated, but a part of it reacts with the sulphuric acid to form another acid—anhydromonopersulphuric acid. When strong sulphuric acid is electrolysed or treated with hydrogen peroxide, persulphuric acid is formed, but the excess of sulphuric acid converts some of it to anhydromonopersulphuric acid. It forms a whole series of salts, of which the potassium salt is the least soluble. *See* POTASSIUM COMPOUNDS.

ANHYDROMONOPERSULPHURIC ACID (Caro's acid): Monopersulphuric acid has the formula $SO_2\left\langle\begin{matrix}O-OH,\\OH\end{matrix}\right.$ but it is unknown. Its anhydride, therefore, will have the formula

$$SO_2\left\langle\begin{matrix}O-OHHO-O\\O\end{matrix}\right\rangle SO_2$$

which is Caro's acid. This acid is not known pure, but forms a pretty stable sulphuric acid or phosphoric acid solution, which also contains persulphuric acid. Such a solution may be obtained by grinding one part of potassium persulphate with two parts of concentrated sulphuric acid, allowing to stand an hour, pouring on to ice, and precipitating sulphuric acid by barium phosphate. That it has the anhydride formula is shown by the fact that its calcium salt on hydrolysis decomposes thus:

$$CaS_2O_9 + H_2O = CaSO_4 + H_2SO_4 + 2O$$

Caro's acid is much used as an oxidising agent in organic chemistry. *See* NITROSO COMPOUNDS.

THIOSULPHURIC ACID, $H_2S_2O_3 = SO_2\left\langle\begin{matrix}OH\\SH\end{matrix}\right.$. The free acid is unknown, for when an acid is added to a thiosulphate to liberate thiosulphuric acid, the liberated acid immediately begins to decompose—

$$H_2S_2O_3 = H_2O + SO_2 + S$$

See THIOSULPHATES *and* SODIUM COMPOUNDS. Other sulphur acids are known, *e.g.* Dithionic acid, $H_2S_2O_6$; Trithionic acid, $H_2S_3O_6$, etc., up to Hexathionic acid, $H_2S_6O_6$. For other inorganic sulphur compounds *see* CARBON DISULPHIDE, HYPOSULPHUROUS ACID, *and* HYPOSULPHITES. Many organic sulphur compounds are known (*e.g. see* MERCAPTANS, MUSTARD OILS, SULPHONIC ACIDS). When four different monovalent atoms or radicals are united to a sulphur atom, stereoisomerism is possible (asymmetric sulphur atom). Thus, when *a*-bromacetophenone and methylethyl sulphide are allowed to act on each other, they readily react to form methylethylphenacylsulphine bromide—

$$\begin{matrix}CH_3\\C_2H_5\end{matrix}\Big\rangle S + BrCH_2CO\,.\,C_6H_5 = \begin{matrix}CH_3\\—\end{matrix}\Big\rangle S\Big\langle\begin{matrix}CH_2COC_6H_5\\Br\end{matrix}$$

This compound, when boiled in alcoholic solution with silver *d*-bromocamphorsulphonate, yields a salt which by fractional crystallisation can be separated into the *d*-bromocamphorsulphonate of the lævo-base, which is the less soluble, and the *d*-bromocamphorsulphonate of the dextro-base, which is contained in the mother liquors, and is purified by crystallisation from acetone.

Sulphuric Acid Manufacture. CHAMBER PROCESS: The "chamber" into which the nitroxygen gases, sulphur dioxide, and steam (or atomised water) are led in order to form the "rain" of acid is a large rectangular arrangement composed of a "saucer" and "curtain" (*q.v.*) usually supported on a floor carried by brick pillars about 12 or 15 ft. above the ground. The curtain is suspended by straps of sheet lead from a wooden framework or scaffolding. The yield of acid is gauged by the "acid drip" (*q.v.*) The sulphur dioxide passes up the Glover Tower (*q.v.*) before entering the chamber, while the exit gases are scrubbed with sulphuric acid in a Gay Lussac Tower (*q.v.*) in order to retain any nitroxygen gases that may escape. These are returned to the chamber by means of the Glover Tower. The resultant chamber acid is syphoned out of the saucer and concentrated to a specific gravity of 1·7. It is also further rectified in glass or platinum lined retorts. The commercial products are known as B. O. V. (Brown Oil of Vitriol) and R. O. V. (Rectified Oil of Vitriol). The size and disposition of the chambers are of importance. It is now customary to allow 12 or 13 ft. of chamber space per lb. of sulphur burnt; also the chambers should be at least four times as long as they are high. The introduction of the gases at the bottom of the chamber is now accepted as preferable. The object of such large chambers is to dissipate the heat evolved during the chemical reaction. The introduction of PLATE TOWERS between the chambers, in a series, is now often adopted, the passage of the gases being assisted and controlled by fans. These plate towers are rectangular or round, and are packed with porcelain saucers or reticulated plates about 3 ft. in diameter, down which water or weak acid passes, meeting the gases as they ascend. A system of tangential chambers is being introduced, but at present is only in the experimental stage, though on the large scale. The nitroxygen gases required (*vide* Chamber Reactions, *supra*) are always obtained by heating cubic nitre (nitrate of sodium), commonly known as Chili saltpetre, with sulphuric acid in nitre pots. The source of the sulphur is of considerable importance, and the finished product is generally classified for trade purposes as pyrites acid, spent oxide acid, and brimstone acid, according to the source of sulphur. There is always the risk of arsenical contamination when iron pyrites (FeS_2) is used (*see* PYRITES BURNER), which is objectionable in the case of acid destined for use in the brewing or mineral water industries. Brimstone acid is the purest for such purposes, being made with sulphur dioxide obtained by burning Sicilian sulphur. Spent oxide acid is also virtually a pure sulphur acid, since spent oxide is hydrated oxide of iron which has been saturated with sulphur compounds and free sulphur in the purification of coal gas (*q.v.*) It is often preferred on this account for the manufacture of sulphate of ammonia, which is largely used as a fertiliser, in which arsenical compounds would be objectionable. Care must be exercised when working with unwashed spent oxide, or trouble will be experienced with the acidity of the chamber exit, which is restricted by law to 4 grains per cubic foot, calculated as sulphuric anhydride. The average acidity from all chambers in the United Kingdom during the past few years has been about 1·2 grains per cubic foot. Some spent oxides rich in ammonia and other nitrate-consuming compounds cannot be used without previous washing. Though the chemistry of the formation of sulphuric acid is at first sight comparatively simple, the actual reactions taking place in the chamber have long been the subject of much controversy. The loss of nitre has always been a mystery that it has been sought to solve by many theories. Undoubtedly the amount of steam admitted into the chamber has much to do with successful working, though this has to be regulated so as to keep the yield of chamber acid at or below 1·6 sp. gr. The careful working of the Gay Lussac Tower is another important factor, particularly in

relation to the loss of nitre. Thanks, however, to physio-chemical researches in connection with the fractional distillation of liquefied gases, it has been possible to dispose of most theoretical arguments concerning the loss of nitre, for in this way it has been proved that the loss is due to mechanical conditions arising from working on a large scale. There is practically no chemical loss, and hydroxylamine products are not formed in the normal working of a chamber (J.S.C.I. vol. xxiii. p. 643). The establishment of this fact is of great assistance, as it points directly to the sections of the plant which must be watched for the leakage of nitre. By the aid of the Plate towers the loss has been reduced to 1·3 parts per 100 of sulphur. CATALYTIC OR CONTACT PROCESS: This method is confined to the production of sulphuric anhydride (SO_3) and very concentrated sulphuric acid, chiefly in Germany and the United States of America. In 1888 only 18,500 tons were being produced by one contact process, which in 1900 had increased its output to 116,000 tons. In 1903 there were twenty-three plants abroad working the Schroeder contact process, apart from other patents. In this country, however, there are only three works—two in England and one in Scotland. Much difficulty is experienced in keeping the acid exit below the legal limit, and H.M. Chief Inspector of Alkali. etc., Works, expresses the opinion that, owing to the limited uses for such concentrated acid, the extension of this process is not anticipated. It is cheaper than concentration for the production of SO_3, but for acid below 60° B. it cannot profitably compete with the chamber process. The process has been briefly described under SULPHUR TRIOXIDE (*vide supra*), but the following additional points are of interest. The contact material requires to be kept at about 400°. There is no reaction at 200°, but at 900° dissociation takes place, the trioxide formed from the mixture of SO_2 and air (1 : 3) reverting to the dioxide. As in the chamber process, it is most important to remove the heat of the reaction, which in this case amounts to 22,600 calories. The composition of the mixture of SO_2 and air, and also the rate of flow, are factors affecting the production. The presence of arsenic in pyritic SO_2 is very soon fatal to the contact material, and great care has to be exercised in keeping this and other impurities out of the reacting gases. A vast number of catalytic agents have been suggested, but platinised asbestos or other allied material has so far been found best. The process is thus shown to be essentially a refinement of the laboratory method operated by Sir Humphry Davy in 1817.—C. H. N.

Sulphuric Ether (*Chem.*) A common name for ETHER (*q.v.*)

Sulphur in Iron (*Met.*) A small amount of sulphur renders iron RED SHORT or brittle when at a red heat; it also destroys its welding properties. The addition of manganese lessens the deleterious effect of the sulphur.

Sulphuryl Chloride (*Chem.*) *See* SULPHUR COMPOUNDS.

Sumach (*Botany*). The finely ground leaves of Sicilian Sumach, *Rhus Coriaria* (order, *Anacardiaceæ*), and the myrtle-leaved Sumach, *Coriaria Myrtifoliæ*, both cultivated in Southern Europe, constitute the tanning material known as sumach. *See also* DYES AND DYEING.

Summer Solstice (*Astron.*) *See* SOLSTICES.

Sump (*Mining*). Any excavation below the floor of a mine, especially a pit in which water collects.

Sun (*Astron.*) (1) The nearest of all stars and the centre of our system. A hot self-luminous body. Mean distance, 93,000,000 miles; diameter, 866,400 miles; period of rotation about 25d. 7h. The surface of the sun, the PHOTOSPHERE (*q.v.*) has a grey background covered with granular forms termed NODULES or RICE-GRAINS. Above this is the CHROMOSPHERE (*q.v.*), in which occurs the REVERSING LAYER whence the Fraunhofer's lines (*q.v.*) are supposed to originate. The FACULÆ (*q.v.*) are found in all parts. Beyond all these is the CORONA (*q.v.*), to be observed only during eclipses. The material of the sun, as revealed by the spectrum, has many elements that are known on the earth, while others have no counterparts. (2) Any star that is the centre of a system.

Sun and Planet Motion (*Eng.*) A device employed by Watt in place of a crank; this use is now obsolete; but it is now used in certain forms of Speed Gears (*q.v.*)

Sun Dial (*Astron.*) A rod termed a Gnomon or Style casts a shadow on a suitably divided plate. The position of the edge of the shadow indicates the Apparent Solar Time. *See also* MEAN SOLAR DAY.

Sunk Winding (*Elect. Eng.*) Conductors laid or wound in slots or grooves in the surface of an armature.

Sunk Work (*Build., etc.*) A recess or sinking below the general surface of an object.

Sunn Hemp (*Botany*). An Indian shrub, *Crotalaria juncea* (order, *Leguminosæ*), producing a valuable fibre for cordage, etc. It is prepared in a similar manner to Hemp and Flax.

Sunshine Recorder (*Metereol.*) An instrument for producing a continuous record (usually on photographic paper) of the time during which the sun shines each day. In some cases the intensity of the radiation received by the instrument is also recorded.

Sun Spot (*Astron.*) One of the apparent dark spots on the disc which appear from time to time, and which move across the disc owing to the solar rotation. Caused by relatively cool matter falling towards the centre from the higher reaches of the solar atmosphere.

Sun Spot Periods (*Astron.*) The number of spots varies from year to year. The interval between the time when there are fewest spots to the next similar condition is about eleven years. There is possibly a longer period of about thirty-five years in addition.

Sunstone (*Min.*) This term is used for any of the Aventurine varieties of the Felspars (*see* PRECIOUS STONES). The characteristic appearance is due to spangles of mica included in the Felspar giving a golden reflection.

Supercalenders (*Paper Manufac.*) A stack of specially arranged polished rolls, used for imparting a very high surface to paper.

Supercooling *or* **Superfusion** (*Phys.*) A liquid which is free from solid particles can usually be cooled some distance below its freezing point if kept still. Movement, or the introduction of a piece of the solid, causes the liquid to solidify with evolution of latent heat and consequent rise of temperature.

Super-elevation (*Eng.*) The raising of the outer rail where a curve occurs in a railway. The object

is to counteract the centrifugal force, which tends to throw the vehicles off the rails when travelling at speed round the curve.

Superheated Steam (*Eng.*) *See* STEAM.

Superior Figures, Superior Letters (*Typog.*) Small figures or letters on the shoulder of type, used as references to footnotes, abbreviations, etc., *e.g.* ¹²³, ᵃᵇᶜ, N°· for number, ° for degree.

Superior Planets (*Astron.*) Those whose orbits lie outside that of the Earth, *i.e.* those which are more distant from the Sun. They are Mars, the Asteroids, Jupiter, Saturn, Uranus, and Neptune (*q.v.*)

Supernumerary Bows (*Meteorol.*) *See* RAINBOWS.

Super-octave (*Music*). A coupler in an organ which causes the note an octave above the note played to fall. *Cf.* SUB-OCTAVE.

Superphosphate (*Chem. Tech.*) A commercial term for monobasic phosphate of lime (*i.e.* soluble phosphate). Largely used as a source of phosphorus in the manufacture of compound fertilisers. Obtained by treating ordinary mineral phosphates (tribasic phosphate of lime), such as Somme, Florida, Algerian, or Carolina phosphate rock or pebbles, coprolites, etc., with sulphuric acid. Unless the tribasic phosphate is thoroughly converted by acid, there is a tendency to "revert" to dicalcic phosphate, which is insoluble.

Superphosphate of Lime (*Chem.*) *See* CALCIUM COMPOUNDS.

Super Royal (*Paper*). Printing paper of size $27\frac{1}{2} \times 20\frac{1}{2}$ in.; writing paper, 27×19 in.

Supersaturated Solutions (*Chem.*) *See* SOLUTIONS.

Supersaturation (*Phys.*) A saturated solution in which no solid particles of the dissolved substance are present can be cooled without deposition. The solution then contains more of the dissolved substance than corresponds to a saturated condition, and is said to be Supersaturated.

Supertonic (*Music*). Above the tonic. The technical name of the second note of a scale.

Supplement of an Angle. The difference between the angle and 180° or two right angles.

Supply Mains (*Elect.*) The mains or principal conductors by which electricity is distributed.

Supply Steam (*Eng.*) The steam at entrance to a cylinder, as distinguished from the EXHAUST STEAM.

Supporters (*Her.*) The figures which appear on each side of a shield, holding up or protecting the same. Their origin is uncertain. Supporters are borne by peers of the realm, by their sons who enjoy honorary titles, and by knights of various orders. They are also borne by persons of other rank, who have derived them from ancestors entitled to bear them. Spiritual peers do not bear supporters.

Surbase (*Architect.*) The cornice or upper moulding of a pedestal (*q.v.*)

Surcoat (*Cost.*) A loose outer garment; specifically, a loose, sleeveless coat or robe worn over armour in the Middle Ages, and girt in at the waist by the sword belt. The later examples were generally emblazoned with the arms of the wearer.

Surface Carburetter (*Motor Cars, etc.*) A form of vaporiser for petrol engines, in which a large surface of liquid is exposed to contact with air, evaporation occurring at the ordinary temperature of the atmosphere. In the commonest forms a large tank is nearly half filled with the liquid petrol or other motor spirit, and the air in the space above the liquid becomes charged with vapour. From this space the gaseous mixture is drawn into the cylinder through a supply pipe. The supply of air is admitted through a vertical pipe, the upper end of which opens into the atmosphere, while the lower end dips under the surface of the liquid in the tank. As the gaseous mixture is withdrawn, fresh air is drawn into the chamber through this pipe, and it can only reach the space above the liquid by passing through the latter in a series of bubbles, thus promoting evaporation. Valves are fitted for controlling the amount of the gaseous mixture drawn into the cylinder at each stroke, and also for regulating the amount of air in the mixture. The surface carburetter is now little used, on account of its large size and other objections, and the various forms of Spray Carburetter (*q.v.*) have largely superseded it.

Surface Condenser (*Eng.*) The device employed for condensing exhaust steam, without mixing it with cold water. The steam is brought into contact with a cold surface, in the form of a large number of brass tubes. These are cooled by a regular flow of cold water, the CIRCULATING WATER, which may flow through the tubes while the steam circulates round them, or *vice versâ*. By this means impure water or salt water may be used for condensing the steam, while the latter is kept pure and may be returned to the boiler after condensation. Surface condensation is now universally used in marine engines.

Surface Density (*Elect.*) The quantity of electricity per unit of area of a charged body.

Surface, Equipotential (*Phys.*) A surface such that the potential (*q.v.*) at any point has a constant value. The surface of a charged conductor is an example of an equipotential surface; the equipotential surfaces due to a charged sphere, at a distance from other bodies, are concentric spheres described in the medium surrounding the sphere.

—— **Measurement of.** *See* WEIGHTS AND MEASURES.

Surface Plate (*Eng.*) A plate of metal (or glass) whose surface has been made as nearly as possible a true plane. It is used for testing the accuracy of a plane surface such as that required to be produced on a slide valve, etc.

Surface Water (*Build.*) Rain water which collects on the surface of the ground and is generally carried off by drains.

Surfacing (*Eng.*) (1) Turning up a plane surface in the lathe; this is only possible when the surface is at right angles to the axis of the lathe. The tool moves across the lathe bed, at right angles to the axis; the slide rest is actuated either by hand or by gearing connected with a back shaft running along the back of the lathe bed; this shaft is itself rotated at a convenient speed by belts, etc., driven by the mandrel of the athe. (2) The term "surfacing" is also occasionally applied to the production of plane surfaces by comparison with a Surface Plate (*q.v.*),

irregularities being gradually removed by a SCRAPER (*q.v.*) This process, however, is more usually termed SCRAPING.

Surfacing Lathe (*Eng.*) Any lathe provided with mechanism for SURFACING (*q.v.*)

Surmounted Arch (*Build.*) A stilted semicircular arch, *i.e.* a semicircular arch rising more than its span or radius.

Surveying. Surveying, in the widest sense, embraces the operations by which are determined the form, dimensions, and levels of portions of the earth's surface, and of various works and structures permanently located thereon. These operations fall for the most part into three classes: (1) Measurement of Distances. (2) Measurement of Angles. (3) Levelling. (1) *Measurement of Distances.* This is effected in the great majority of practical cases by a CHAIN, whose length is usually 66 ft. (or in certain cases 100 ft.) The links, 100 in number, are made of straight pieces of steel wire, about 6 in. in length, with a loop at each end; consecutive links are joined by small loops, which, with the straight link, give a total length of 7·92 in. per link; every tenth link is numbered by means of a small brass tally. Points are marked by rods or ARROWS stuck into the ground where the end of the chain rests at each measurement; the ends of a line, or other important points or STATIONS, are marked by poles termed RANGING POLES, which are painted in prominent colours and may have a flag attached. Small distances may be measured with a TAPE, preferably of steel, or with MEASURING RODS. (2) *Measurement of Angles.* (*a*) The chain may be used in cases where the angle to be measured forms one of the angles of a triangle whose sides can be measured on the ground; the length of the three sides being known, the triangle is completely determined. (*b*) The majority of angular measurements are made by the THEODOLITE. This is in principle a telescope which can be turned about on either a vertical or a horizontal axis, the angles of rotation being measured by graduated circles provided with VERNIERS (*q.v.*) For ordinary measurements of horizontal angles, the instrument is set up at the apex of the angle to be measured, and the telescope is directed at a suitable object which is situated in one of the lines containing the angle; a ranging pole is often set up for this purpose. The vernier reading of the horizontal scale is then read, the telescope directed at a pole or other object in the second line containing the angle, and the vernier read again. The difference of the two readings is the angle required. When used for measuring vertical angles (*e.g.* in measuring the height of a lofty object), the telescope is rotated about the horizontal axis and the readings taken from the vertical circle. (*c*) For rough surveys or for filling in small details, the PRISMATIC COMPASS is often used. This is a magnetic compass having a "floating card," *i.e.* a circular card divided into degrees, and attached to the needle so as to turn with it; the instrument is provided with sights which are aligned with any given object; by means of a reflecting prism the sights and the graduations of the scale may be read simultaneously. Thus the angle between any given line and the direction in which the compass points may be read off. (*d*) The MINER'S DIAL, or CIRCUMFERENTER, is a compass of larger size than the foregoing, provided with sights which can be turned relatively to the box; the object is viewed through these sights, and the angle made by the line of sight with the direction of the needle read off. (*e*) The SEXTANT (*q.v.*) is sometimes used in angular measurement, a small portable form termed the BOX SEXTANT being very convenient for explorers. (3) *Levelling.* The LEVEL consists essentially of a telescope mounted on a vertical axis (without a graduated circle). A spirit level is contained in a "level tube" which is attached to the telescope, and provided with means of adjustment so that the axis of the telescope can be made accurately parallel with that of the level itself: thus when the bubble of the level is in its central position, the axis of the telescope is truly horizontal. In using the instrument to determine the difference of level of two adjacent points, a LEVELLING STAFF is set up at each station; this is a graduated rod of convenient height, the divisions being clearly marked so as to be distinctly visible through the telescope. If the instrument be placed between the stations, and turned so as to view the graduations of each staff in turn, the difference of the readings on the two staves gives the difference in level of the two points on which the feet of the staves are placed, provided that the instrument has first been correctly adjusted. For observing great differences in level, such as the height of a mountain, some form of barometer is often used, or the change in levelling point may be measured by the hypsometer (*q.v.*) Many other instruments are also used in surveying; for descriptions of these, works on Surveying must be consulted.

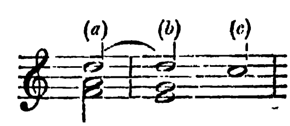
Susceptibility, Magnetic (*Elect.*) The ratio of the induced magnetism in a piece of iron, etc., to the magnetising force. If I be the Intensity of Magnetisation (*q.v.*) and H the magnetising force, the ratio of I to H is termed the MAGNETIC SUSCEPTIBILITY, and usually denoted by the letter k, so that $k = \frac{I}{H}$.

Suspended Coil Galvanometer (*Elect.*) *See* GALVANOMETERS.

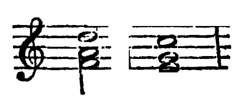
Suspended Magnet Galvanometers (*Elect.*) *See* GALVANOMETERS.

Suspended Solidification (*Chem.*) When a solid has been melted and allowed to stand protected from dust and vibration, it will remain liquid for some degrees below its melting point. This phenomenon is known as suspended solidification: it is a particular case of a perfectly general resistance to change of phase. The liquid will solidify if a trace of the solid is thrown into it, and in doing so its temperature will rise to its melting point. The rate at which the liquid reverts to the solid phase varies with the temperature to which it has been cooled below its melting point, except when it has been very suddenly cooled to a temperature far below this point. In such a case the "liquid" has really become an amorphous solid, which will only revert to the crystalline state very slowly.

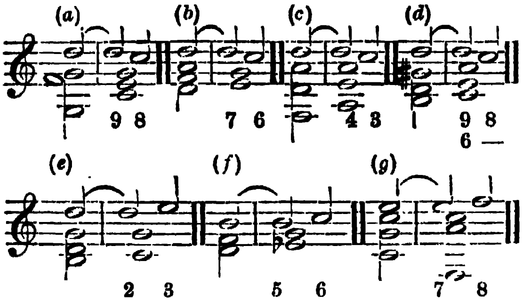
Suspension (*Music*). The holding back of one or more notes whilst the remainder of the chord moves, as



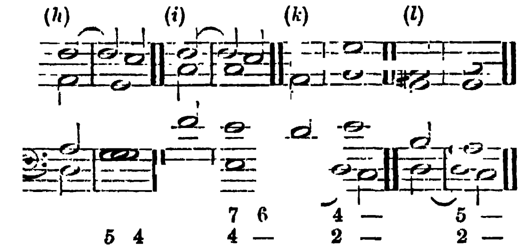
instead of



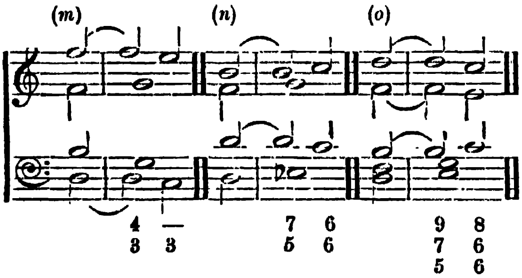
The note D at (*a*) is called the PREPARATION, at (*b*) the PERCUSSION, and at (*c*) the note C is the RESOLUTION. The most usual of the suspensions are the 9-8 (*a*), and its inversion 7-6 (*b*); the 4-3 (*c*) and its inversion (*d*) making a 9-8 over a first inversion; the 2-3 (*e*); the 5-6 over the mediant in the minor key (*f*) also found over the leading note; and the 7-8 (*g*). The last three are sometimes called RETARDATIONS (*q.v.*)



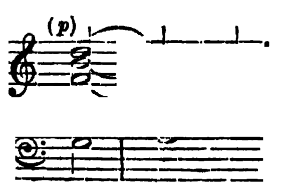
Besides these there are the second inversion of the 9-8 (*h*), making a 5-4 over 6; the second inversion of a 4-3 (*i*) making a 7-6 over 4; the 9-8 in the bass (*k*) and the 4-3 in the bass (*l*).



Two or more of these suspensions may be taken together, as, for instance, the 9th and 4th (*m*), (where the 9th is shown in the bass); the 5th and 7th (*n*); the 9th, 7th, and 5th (*o*). These are known as double suspensions.



There is also the suspension of a complete chord as at (*p*).



See also last four bars of first variation of the Andante of Beethoven's Sonata in G, Op. 14, No. 2. It will be seen that (1) the note or notes suspended are always essential notes of the "preparation" chord, and never of the "percussion" chord; (2) that the suspension moves by step of a second; (3) that the "preparation" chord must not be at a stronger part of the bar than the "percussion" chord. If the preparation is shorter than the percussion, it is better to restrike the suspension than to tie it.

Suspension (*Phys.*) The device by which a light object, such as a galvanometer needle, is supported, so as to be able to turn easily about a given axis. The most usual suspensions are fibres of unspun silk, quartz fibres, and fine wires, or strips, usually of phosphor bronze. The term is also sometimes applied to a support formed by a pivot or a knife-edge.

Suspension Bridge (*Civil Eng.*) A bridge consisting of one large span, or occasionally more, supported at suitable intermediate points by cables or tie rods placed above the roadway, and therefore in tension. The most usual type has a tall tower at (or near) each end of the bridge; between these towers are suspended heavy chains, from which vertical rods are hung to support the bridge proper. The chain is prolonged beyond each tower on the land side, and made fast to the ground by means of masonry, etc., in order to balance the force tending to overturn the tower.

Suspension Links (*Eng.*) Rods or bars by which the slotted link of the LINK MOTION (*q.v.*) in a locomotive, etc., is moved.

Svegliato (*Music*). Awakened.

Swab (*Foundry*). A soft brush or mop used for wetting the parting edge of a mould before the pattern is withdrawn.

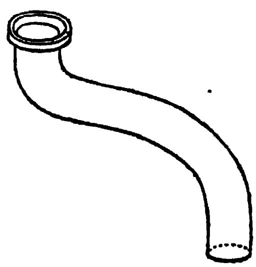
Swage (*Eng.*) A piece of iron or steel of the nature of a die, used in giving some required shape to a forging.

Swage Block (*Eng.*) A large piece of metal containing various holes, grooves, etc., used as swages (*q.v.*)

Swaging (*Eng.*) Shaping a forging by means of SWAGES or dies (*q.v.*)

Swansea (*Porcelain*). A manufactory of earthenware was established at Swansea in 1750. In 1814 Mr. Dillwyn acquired the works and proceeded to make porcelain with the assistance of William Billingsley, who came from Nantgarw. The porcelain was a remarkably fine soft paste, and excellent artists were employed. The manufactory was closed in 1820. The chief characteristics of Swansea porcelain are a fine dark blue and beautifully executed paintings of flowers. *For* MARKS *see under* POTTERY AND PORCELAIN.

Swan's Neck (*Plumb.*) A pipe with a double curve (concave and convex).



SWAN'S NECK.

Swarf (*Chem. Tech.*) The scrapings and chippings from soft iron castings. Used as a reducing agent in aniline manufacture.

—— (*Eng.*) Fine particles of metal, removed by a cutting tool; or particles of sand, etc., worn off a grindstone.

Swash Letters (*Typog.*) The name given to a style of italic capital letters, with tails and flourishes, in vogue in the seventeenth century. Example, *N*.

Swash Plate (*Eng.*) A disc keyed on the end of a rotating shaft in such a way that its plane is not at right angles to the shaft; it is used to communicate a reciprocating motion to a rod which rests on it.

Sweating (*Chem. Tech.*) *See* Manufacture of Paraffin Wax *under* PETROLEUM.

—— (*Eng., etc.*) Joining metal objects by filling in or surrounding the joint with solder and flux and then heating by means of a soldering iron, lamp, or blowpipe until the solder "runs."

—— (*Leather Manufac.*) Hides and skins are hung in a warm damp chamber, and allowed to sweat until the hair or wool is loose enough to be "pulled" or removed. This process is no longer employed in this country for hides, but is largely used in the treatment of sheepskins.

Swedge (*Eng.*) *See* SWAGE.

Swedish Iron (*Met.*) Iron made from certain Swedish iron ores which are very free from sulphur and phosphorus; it is smelted with charcoal, thereby avoiding the introduction of the impurities always found in coal and coke. It is of great value for the manufacture of crucible cast steel, and for the production of soft wrought iron for electrical work (*e.g.* armature and transformer cores).

Sweep. (1) A curve. (2) A curved STRICKLE (*q.v.*)

Sweeping Up (*Moulding*). STRICKING or STRICKLING (*q.v.*)

Sweep Saw (*Carp.*) A COMPASS or PAD SAW, used for cutting curves. *See* SAWS.

Sweet Spirits of Nitre (*Chem.*) *See* ETHYL NITRITE.

Swell (*Cotton Weaving*). A small lever of the third order placed in the shuttle box back of a fast reed loom. The shuttle acts upon it in connection with the shuttle protector.

—— (*Music*). The part of an organ that has the pipes enclosed in a box, called the swell box. *See* MUSICAL INSTRUMENTS, p. 440. The first swell was made by Jordan at the beginning of the eighteenth century.

Swifts (*Woollen Manufac.*) *See* CARDING ENGINE.

Swing (*Eng.*) The swing of a lathe is the radius of the largest piece of material which can be turned in it.

Swing Back (*Photo.*) A frame which is hinged to the camera in such a way that the dark slide and its contained plate can be brought vertical when the camera has to be tilted.

Swing Bridge (*Civil Eng.*) A movable bridge of which the separate parts turn in a horizontal direction, *i.e.* about a vertical pivot or axis. A good example is the swing bridge over the Dee at Hawarden, which is about 285 feet long. The pivot of this bridge is 116 feet from the end, thus dividing it into two unequal parts, of which the longer extends over the channel. A counterpoise weight of over 100 tons is carried by the shorter or tail end, and the total weight of the moving part is 750 tons. This bridge can be opened so as to give an opening of 140 feet in 2½ minutes.

Swiss Machine (*Lace Manufac.*) The usual form of embroidery machine employed in Switzerland and other countries for producing embroidery upon net or other fabric.

Switch (*Civil Eng.*) The device used for effecting a junction of one set of rails with another. *See* RAILWAYS.

—— (*Elect.*) A device for making and breaking the electrical connection in a circuit.

Switchback (*Civil Eng.*) A form of siding used on some American railways in carrying a line up very steep slopes. The line forms a series of zigzags, and at each point where two straight lengths meet is the siding, the lines forming a letter Y. The train is drawn into the tail of the Y, the engine is then attached to the other end, and the train drawn out along the other branch.

Switch Board (*Elect. Eng.*) A support carrying switches, terminals and connectors, and various measuring instruments, by which the connections of a complex system of electric circuits are made and controlled at a Central Station.

Switch, Double Pole (*Elect. Eng.*) A switch which makes and breaks contact in both terminals of an electric circuit. The part of the circuit controlled by the switch is entirely cut off from the remaining or "live" part when the switch is opened.

Switching (*Elect. Eng.*) Operating a SWITCH (*q.v.*)

Switch, Single Pole (*Elect. Eng.*) A switch which breaks the electrical connection in one terminal only of a circuit.

Swivel. (1) A joint hinging or turning on a pin. (2) In gasfitting a joint that will turn horizontally.

Swivel Weaving (*Cotton Weaving*). A method of ornamenting good qualities of cloth by means of a series of small shuttles containing weft of character and colour different from the ground. By this means small weft spots, sprigs, etc., are produced. There are two forms—Horizontal Swivel, Circle Swivel.

Sycamore. *See* WOODS.

Syenite (*Geol.*) A Plutonic rock having granitic structure (*q.v.*), but of a less acid character than granite—*i.e.* containing from 60 to 65 per cent. of silica. A typical syenite contains orthoclase felspar and hornblende, but no free quartz. Varieties, however, occur which contain a little quartz; these are known as QUARTZ SYENITES. Other forms are termed AUGITE SYENITE, MICA SYENITE (or MINETTE), etc., from the presence of these minerals. The name is derived from Syene, in Upper Egypt, where the rock originally termed Syenite occurs; this rock was used in ancient times for architectural and ornamental work.

Sylvanite (*Min.*) A synonym for Graphic Tellurium (*q.v.*)

Sylvine (*Min.*) Potassium chloride, KCl; potassium = 52·5, chlorine = 47·5 per cent. Cubic; colourless or white. One of the salts found in the salt mines of Stassfurt; also as a volcanic product on Vesuvius.

Symbols, Chemical. *See* CHEMICAL SYMBOLS.

Symmetric Planes of a Lens (*Light*). A pair of planes drawn through the SYMMETRIC POINTS (*q.v.*) of a lens, at right angles to the axis.

Symmetric Points of a Lens (*Light*). Two points on the axis of a lens each being at a distance from the nearest Principal Point, equal to twice the Focal Length.

Symmetry. The harmonious proportion or balancing of the parts of a design or body relative to each other.

Sympathetic Inks (*Chem.*) *See* INKS.

Symphony (*Music*). *See* SONATA.

Synchroniser (*Clocks*). A mechanism, generally actuated by an electric current, for making clocks keep identical time. *Cf.* JOURNEYMAN.

Synchronising (*Phys.*, *Elect. Eng.*, *etc.*) The regulation of two (or more) machines or pieces of apparatus so that their movements or effects produced by them occur simultaneously: *e.g.* two alternators which are to be run in parallel must produce currents which not only possess the same frequency, but the same phase (*q.v.*), so that their maxima and minima occur at identical times.

Synchronous Charts (*Meteorol.*) Charts which present the principal elements of the weather at any given instant.

Synchronous Motor (*Elect. Eng.*) An alternating current motor which must keep in phase with the alternating current which drives it. Its speed is therefore absolutely fixed by the frequency of the supply. *See* MOTORS, ELECTRIC.

Syncline or **Synclinal Structure** (*Geol.*). Strata bent into a trough-like form, so that the beds dip towards the axis about which the folding has occurred. *Cf.* ANTICLINAL.

Syncopation (*Music*). A false accent produced by prolonging a note begun on an unaccented part of a bar over a more accented part. It is generally marked by an accent >.

Synodic Month (*Astron.*) The interval of time between one conjunction (*q.v.*) of the moon and the succeeding one.

Synodic Period (*Astron.*) The time in which a planet returns to the same position with regard to the sun and earth.

Synoptic Charts (*Meteorol.*) *See* SYNCHRONOUS CHARTS.

Synthesis (*Chem.*) The building up of a compound from its elements. Thus, when hydrogen burns in oxygen, water, which is the product of the combustion, is built up from its elements or synthesised. In speaking of the synthesis of organic compounds—say, for instance, of glucose and indigo—when the chemist says that these have been synthesised, he really means that if it were necessary they could be built up from their elements: for in such cases the starting point for the synthesis is a fairly complex body, which could, if required, be made from its elements. Glycerine and naphthalene are substances which could be made on a large scale from their elements, but the processes would be long and costly; nevertheless, as glucose and indigo respectively can be artificially made from these, they are said to have been synthesised. Before a compound can be synthesised, its constitution must be known; then, as a rule, the compound can be synthesised; but even then a synthesis may prove exceedingly difficult; the constitution of camphor was known long before it could be synthesised.

Syphon. *See* SIPHON.

Syren. *See* SIREN.

System (*Geol.*) A group of formations (*q.v.*) which occur in association with one another, and which contain a closely related set of fossils; *e.g.* the CRETACEOUS SYSTEM, including the Chalk, Greensands, and the Wealden Rocks. *See also* STRATA, TABLE OF (*in Appendix*).

Systems of Crystals (*Min.*) A crystal system is a group of crystals, all the members of which have certain similar properties as regards the lengths and mutual inclinations of their axes, and as regards symmetry of form. If a comparison be made of the lengths of the axes cut off by the several planes of a crystal (the INTERCEPTS of these planes), it is found that these lengths bear a definite and comparatively simple relation to one another. Suppose a certain plane is found to cut off, on three axes meeting in a common point called the Origin, three unequal lengths, a, b, c; the intercept of other planes on these three axes taken in the same order are found to bear to a, b, c, some such simple relation as a, b, $3c$, or $2a$, $2b$, $5c$, or $\infty\, a$, b, c. Then the lengths a, b, c, are called the PARAMETERS of the crystal, and it is these parametral lengths which have to be considered in classifying crystals according to their systems. It is found that all crystal forms of one mineral have intercepts on the axes which can be expressed in simple integral terms (positive or negative, and including zero and infinity) of a, b, c, the integral numbers in most cases not being higher than 7. The intercept of a plane on one of the axes may seemingly be a fraction of the parametral length, as $\frac{a}{2}$, b, $2c$, but since for crystallographic purposes planes that are parallel and on the same side of the origin are identical, these intercepts can be expressed as a, $2b$, $4c$.

Since the parametral lengths are taken as units once their values are determined, the intercepts of any plane may be stated by using the numerators of a, b, c; *e.g.* in the above instance the intercepts can be expressed by *1 2 4*. But it is usual to employ the reciprocals of the intercepts as the *Index* of a form; hence the plane in question would be designated *4 2 1*, the whole numbers proportional to $\frac{4}{4}, \frac{2}{4}, \frac{1}{4}$ or $\frac{1}{1}, \frac{1}{2}, \frac{1}{4}$.

The symmetry of a crystal depends on the possible number of planes along which the crystal may be divided into symmetrical portions.

There are six crystallographic systems, as tabulated below (some of the more common synonyms of each system being given):—

I.	II.	III.
Cubic	Tetragonal	Hexagonal
Isometric	Dimetric	A. Hexagonal Division
Monometric	Quadratic	
Regular	Pyramidal	B. Rhombohedral Division
Tesseral		

IV.	V.	VI.
Rhombic	Monosymmetric	Triclinic
Trimetric	Monoclinic	Asymmetric
Orthorhombic	Oblique	Doubly Oblique
Prismatic	Clinorhombic	Anorthic

I. CUBIC SYSTEM. Three axes (a) of equal length and at right angles. There are three equal planes

of symmetry having their intersections in the lines of the three axes, and six diagonal planes of symmetry equal in themselves.

II. Tetragonal System. Three axes at right angles, the two horizontal ones (a) being equal, and the vertical one ($\acute{c}$) being either longer or shorter than the others. There are three planes of symmetry intersecting in the axes, two of them equal, and two diagonal planes equal to one another.

III. Hexagonal System. This includes (A) the Hexagonal group proper, and (B) the Rhombohedral division.

In (A) there are three axes (a) of equal length inclined to one another at 60°, and a third ($\acute{c}$) vertical to the plane of the others through the origin. The vertical axis may be longer or shorter than the others. There are four axial planes of symmetry, three equal radial planes and a horizontal plane unequal to the others. There are also three diagonal planes equal in themselves.

In (B) the axes may be regarded as only three in number, equal and inclined to one another at equal angles, and lying in the three radial symmetrical planes of the hexagonal division. There are three planes of symmetry, intersecting at 120° to the vertical and coinciding with the three radial axial planes of the hexagonal division. Rhombohedral forms may be regarded as hemihedral forms (those with only alternate faces developed) of the hexagonal group. A hemihedral form of the rhombohedral group would correspond to a tetartohedral of the hexagonal (the fourth face only being developed).

IV. Rhombic System. Three axes at right angles, $\breve{a}$, $\bar{b}$, $\acute{c}$, all unequal, and three planes of symmetry intersecting in these axes and all unequal. The right-and-left axis is called the Macrodiagonal, and is designated by $\acute{b}$ and is always taken equal to unity. The front-and-back axis is the brachydiagonal, a; it is less than unity. The vertical axis is $\acute{c}$.

V. Monosymmetric System. Three unequal axes, $\grave{a}$, $\acute{b}$, $\acute{c}$, the two lateral axes being at right angles to one another, but only $\acute{b}$, the orthodiagonal, is at right angles to the vertical axis $\acute{c}$, the clinodiagonal, $\grave{a}$, being inclined to $\acute{c}$ at an angle β. The axis $\acute{b}$ is taken as unity, and $\grave{a}$ is usually less than $\acute{b}$, but not necessarily so. There is only one plane of symmetry, the plane containing $\grave{a}$ and $\acute{c}$.

VI. Anorthic System. Three axes, a, b, $\acute{c}$, all unequal and all inclined to one another, the angle between b and $\acute{c}$ being α, that between a and $\acute{c}$ being β, and that between a and b being γ. In this system there is no plane of symmetry, opposite pairs of faces being only symmetrical with regard to the point called the origin.—W. G.

Systyle (*Architect.*) The name given to the arrangement of the columns in a Grecian temple when the space between the columns is equal to twice the lower diameter of the shaft. *See* Aræostyle, Pycnostyle, Diastyle, *and* Intercolumniation.

Syzygy (*Astron.*) One of the two opposite positions of an orbit which a celestial body is in at Conjunction (*q.v.*) or at Opposition (*q.v.*), *e.g.* the points occupied at new and full moon.

Ta (*Chem.*) The symbol for Tantalum (*q.v.*)

Taa (*Architect.*) *See* Pagoda.

Tabard (*Her.*) A garment shaped something like an overall, reaching nearly to the knee, open at the sides, and with wide sleeves or flaps reaching to the elbows. Worn originally over body armour and generally emblazoned with the arms of the wearer or his lord. Subsequently adopted as a general article of dress. In England the tabard is now worn only by heralds and pursuivants of arms, and bears the arms of the sovereign. *See* Coat Armour.

Tabaret *or* **Taborette** (*Silk Manufac.*) A fabric consisting of alternate stripes of watered tabby (*q.v.*) and satin.

Tabby *or* **Taffeta** (*Silk Manufac.*) A plain fabric formed by the simplest kind of weaving, being always one thread up and one thread down all over—*i.e.* each alternate thread of the warp being raised and the intermediate threads depressed for the first pick, the action on the warp threads being reversed for the second pick.

Tabby Tie (*Silk Weaving*). *See* Tie.

Tabernacle (*Architect.*) (1) The ciborium or baldachino (*q.v.*) over an altar. (2) A canopied niche or stall. The carved openwork used in these canopies is known as Tabernacle Work.

Table (*Eng., etc.*) A horizontal plate on which pieces of material are laid or fixed while being operated upon, *e.g.* the term is commonly applied to the part of a drilling or planing machine which supports the work.

—— (*Gems*). (1) The plane or large flat facet on the top of a brilliant-cut stone. (2) A stone of oval, round, square, oblong, or other form, cut flat on the upper and lower sides, which are bordered by rows of square or triangular facets.

—— (*Glass Manufac.*) The term applied to the circular plate of glass (about 54-70 in. in diameter) which forms the final product in the manufacture of Crown Glass (*q.v.*)

—— (*Math., etc.*) A series of numbers or other quantities arranged in a form convenient for reference—*e.g.* in parallel columns.

—— (*Music*). The upper surface of the board, above the channels of the sound board, in an organ. *See* Musical Instruments, *p.* 439.

—— *or* **Tablet** (*Architect.*) A flat slab or surface usually of rectangular shape, such as a monumental slab. A Raised Table projects from the wall face, and a Raking Table is one which is not vertical.

Table Scarf (*Carp. and Join.*) A scarf joint having a flat surface notched into another piece end to end.

Tablet (*Archæol.*) One of a set of thin plates of wood, ivory, or other material, hinged together, and used for writing upon. The surface of the tablet was coated with a thin layer of wax, which was protected by a raised edge, and the writing was effected by means of a style (*q.v.*)

Table Vice (*Eng.*) A light vice attached to a bench.

Table Work (*Typog.*) Matter consisting of figure work, etc., composed of five columns or more. If with headings four columns or more. *Cf* Tabular Work.

Tablinum (*Architect.*) An apartment in which records were stored in a Roman house. It was situated between the atrium and the peristylium.

Taborette (*Silk Manufac.*) *See* Tabaret.

Tabular Spar (*Min.*) A name for WOLLASTONITE (*q.v.*)

Tabular Work (*Typog.*) Figure work, etc., consisting of three or four columns. *Cf.* TABLE WORK.

Tacet (*Music*). An indication that a certain voice or instrument so marked is to be silent.

Tacheometer (*Surveying*). An instrument for the indirect measurement of distances. The eyepiece of its telescope is furnished with two horizontal cross wires, the arrangements being such that the distance of a vertically held staff, called the stadia (*q.v.*), is determined at once by viewing the latter through the telescope and noting the number of divisions on the staff seen between the cross wires.

Tachometer *or* **Tachymeter** (*Eng.*) A speed indicator; an apparatus for measuring the number of revolutions per minute of some rotating part of a machine.

Tachylite (*Geol.*) A glassy lava of basic composition, *i.e.* corresponding in composition to Basalt (*q.v.*)

Tackle (*Eng.*) A rope or chain and pulley block, or a combination of chains and ropes and pulley blocks, working together and used for lifting heavy weights.

Tackler (*Cotton Manufac.*) An overlooker who keeps the looms in repair and performs other functions necessary to keep them running.

Tacks (*Plumb.*) The ears attached to lead pipes by which they are fixed to the wall.

Tacky (*Dec.*) A condition which is reached when a coat of paint or varnish is not quite dry. This condition is ascertained by placing the finger lightly against the paint or varnish, which will adhere to it slightly if tacky. Paint and varnish sometimes remain tacky for a considerable time owing to an excess of driers, a dirty, greasy surface, or to the varnish having been applied where there is lack of proper ventilation. When gold size (*q.v.*) is used as a medium by which to cause gold leaf to adhere to the letters of a sign or other surface, the gold size is painted on and is allowed to become just tacky before the gold leaf is applied. *See* DRYING OF PAINT, DRYING OILS, *and* VARNISHES.

Tænia *or* **Tenia** (*Architect.*) The fillet on the upper edge of the Doric architrave. *See* DORIC ORDER; ARCHITECTURE, ORDERS OF; *and* ENTABLATURE.

Taffeta (*Silk Manufac.*) *See* TABBY.

Taft Joint (*Plumb.*) A blown joint (*q.v.*)

Tail (*Bind.*) The bottom edge of a book, including paper and cover.

—— (*Build.*) The lower or exposed part of a roofing slate or tile.

—— (*Eng.*) The lower or hinder part of various machines, *e.g.* the vertical rod or support of a fitter's vice.

Tail Bay (*Carp. and Join.*) The end bay of a roof or ceiling.

Tailings (*Leather Manufac.*) Tan liquor that has become "sour."

—— (*Mining*). The refuse material or worthless slimes (*q.v.*) that are rejected in washing an ore that has passed through the stamp mills. The tailings are sometimes subjected to further treatment for the extraction of metal they may contain.

Tail of a Comet (*Astron.*) The stream of light which commonly accompanies a bright comet. The tail is always turned away from the sun.

Tail Piece (*Music*). That part of stringed instruments to which the strings are attached at the lower end.

Tail Pieces (*Typog.*) Ornaments placed in a short page at the end of a chapter, article, or volume, to fill up the vacancy.

Tail Race (*Eng., Mining, etc.*) The race or channel which leads the waste water away from a water wheel or other machinery.

Tail Stock (*Eng.*) The movable head or poppet of a lathe (*q.v.*)

Tail Vice (*Eng.*) The large vice (*q.v.*) used by fitters, blacksmiths, etc.; it has a vertical rod or column, termed the tail, resting on the floor of the workshop.

Tail Water (*Eng.*) The waste water flowing away from a water wheel.

Take (*Typog.*) When copy (*q.v.*) is apportioned to the compositors to be set up in type, the portion falling to each compositor is termed a "take."

Taker Off (*Print.*) The person who releases the printed sheet from the printing press or machine.

Taking Off (*Build.*) Taking measurements from drawings.

Taking Up (*Eng.*) Shortening or tightening fittings, moving parts, etc., which have become elongated or loosened by wear.

—— (*Textile Manufac.*) A motion for automatically winding the cloth as it is woven on to a cloth roller. *See* LOOM.

Taking Up Slack (*Eng.*) Shortening a belt or chain which has become elongated.

Talaria (*Art*). The sandals or greaves, ornamented with wings, which are characteristic of the attire of Hermes (Mercury), Eros, and certain other divinities in classical mythology.

Talc (*Min.*) A hydrous silicate of magnesia. Silica = 62, magnesia 33·1, water 4·9 per cent.; 1 or 2 per cent. of iron and a little alumina often occur as well. Crystals are rhombic, but the mineral is usually found massive, and is easily split into thin plates, which are distinguished from those of Mica (*q.v.*) by not possessing elasticity. Colour white, light or dark green. Common in many localities.

Talking Machine. *See* PHONOGRAPH.

Tallboy (*Build.*) A long chimney pot made of zinc or iron.

Tallow Cup (*Eng.*) A lubricator holding tallow.

Talus (*Geol.*) Débris produced by weathering, which accumulates in sloping heaps at the foot of a cliff.

Tamarind (*Botany*). The fruit of *Tamarindus indica* (*Leguminosæ*) in the form of a preserve is used in pharmacy either alone or in combination with other substances. Its properties are laxative and refrigerant.

Tambourine (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 445.

Tamping (*Met., etc.*) Stopping up a vent or tap hole in a furnace by means of clay.

—— (*Moulding*). Ramming the sand round a pattern.

Tan. The abbreviation used for TANGENT: *see* TRIGONOMETRICAL RATIOS.

—— (*Leather Manufac.*) *See* LEATHER MANUFACTURE.

Tanagra Figurines (*Archæol.*) Small terracotta figures representing divinities and incidents of Greek domestic life, etc. They were usually cast, and after being baked were generally brilliantly coloured. Used as household ornaments and as votive offerings; some of the earliest examples are from the cemetery of Tanagra in Bœotia.

Tandem (*Cycles*). A cycle carrying two riders, one behind the other. Machines of the same type carrying three or four riders, termed TRIPLETS and QUADRUPLETS, are little used except in pacing a racing cyclist.

Tandem Engine *or* **Pump** (*Eng.*) An engine or pump having two (or more) cylinders arranged in the same straight line with one piston rod running right through and carrying all the pistons. *See* STEAM ENGINE.

Tanekaha (*Botany*). A New Zealand pine tree, *Phyllocladus trichomanoides* (order, *Coniferæ*), whose bark, known as Tanekaha, is used in tanning, and as a dye for leather.

Tang (*Carp., etc.*) The pointed end of a tool such as a chisel or gouge, which is driven into the wooden handle.

Tangent (*Math.*) (1) The tangent to a curve is a line touching the curve, but not cutting it. (2) A Trigonometrical Ratio (*q.v.*)

Tangent Galvanometer (*Elect.*) *See* GALVANOMETERS.

Tangent Screw. A screw whose point acts on a radial arm or other device attached to some portion of an instrument or machine in order to obtain an angular motion of small amount; in some cases the screw gears directly into a worm-wheel mounted on the axle of the rotating part. Tangent screws are fitted to spectroscopes, theodolites, and many astronomical instruments.

Tangent Spokes (*Cycles*). Spokes which leave the hub at a tangent to its rim, instead of radially. They are stronger and also easier to replace if broken than "direct" or radial spokes.

Tank (*Civil Eng.*) A reservoir, whether artificially constructed throughout or formed by utilising a natural hollow or depression.

Tank Base (*Eng.*) A hollow casting serving as the baseplate of an engine, etc., and also as a tank or reservoir; *e.g.* in the case of oil engines a considerable supply of oil is often contained in a tank of this kind.

Tank Engine (*Eng.*) A small locomotive carrying a supply of water in a tank fitting over or placed alongside the boiler.

Tank Liquor (*Chem.*) *See* ALKALI.

Tan Liquor (*Leather Manufac.*) A general term used to denote all solutions of the various tanning materials used in the tanyard. *See* LEATHER MANUFACTURE.

Tannic Acid (*Chem.*) *See* TANNINS.

—— (*Eng.*) This acid is used to prevent incrustation of boilers; it forms insoluble compounds with salts of lime, and this can be removed in the form of a scum by blowing off (*q.v.*)

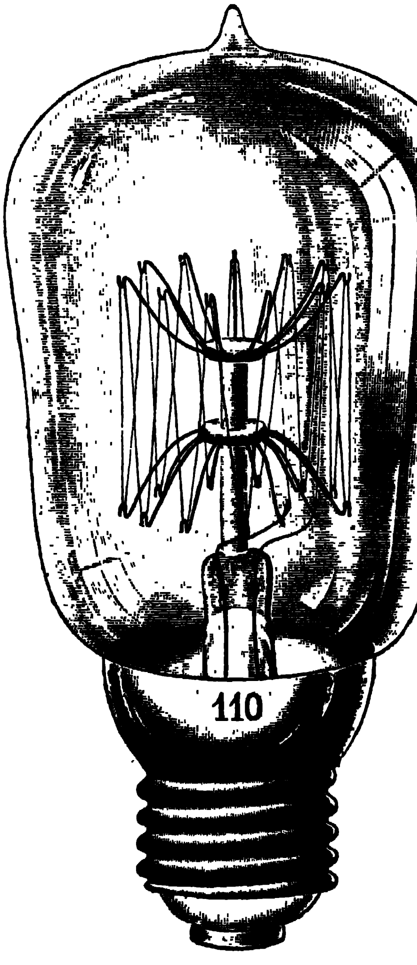
Tanning. *See* LEATHER MANUFACTURE.

Tannins (*Chem.*) Substances of unknown constitution which occur widespread in the vegetable kingdom, have an astringent taste, are soluble in water, their solutions are precipitated by lead acetate, and give a dark blue or green colouration with iron salts. Many give precipitates with gelatine and convert skins into leather; some are glucosides of gallic acids, while others are compounds of phloroglucin and gallic acid. Examples: TANNIC ACID (gallotannic acid: tannin), is nearly colourless when pure, but usually it is met with as a brownish yellow powder; when heated it darkens in colour and gives pyrogallic acid and carbon dioxide. It is soluble in water, giving a dextrorotatory solution; when an alkali is added to the solution, it rapidly absorbs oxygen and turns black. Its solution is easily hydrolysed to gallic acid (*q.v.*) by acids, alkalis, and certain ferments; it reduces Fehling's solution and ammoniacal silver; with iron salts it forms ink; it precipitates gelatine, albumin, starch, the alkaloids; it also gives precipitates with tartar emetic, lead acetate, and a number of other salts. Tannic acid is used as an astringent in medicine, in making ink, in the preparation of gallic and pyrogallic acids, and as a mordant in dyeing. It occurs in gallnuts from various kinds of oak, in sumach, and in tea. It is extracted from finely ground gallnuts by a mixture of aqueous alcohol and ether: the extract separates into two layers, the lower layer containing the tannic acid, which it yields on evaporation. CAFFETANNIC ACID is the tannin found in coffee berries; its solution does not precipitate gelatine, and it gives a green colour with ferric chloride; it is a glucoside. QUERCITANNIC ACID occurs in oak bark and probably in tea.

Tantalum (*Chem.*) Ta. Atomic weight, 183. A rare metal, when pure resembling platinum in colour: melts between 2,250° and 2,300°; sp. gr. 16·5; malleable and very ductile. Its tensile strength is about the same as that of steel, the breaking load for a wire of 1 mm. diameter being 93 kilos. When a lump of tantalum is heated to redness and brought under the steam hammer, it forms a plate which when repeatedly treated in the same way becomes so hard that a diamond will not bore it. The specific resistance for a wire 1 metre long and 1 mm² section is 0·165 ohms. The temperature coefficient is ·003 between 0° and 100°, and between 0° and 350° it is ·0026, and at a consumption of 1·5 watts per candle power it reaches 0·855 ohms. On account of its high melting point and its resistance to "dusting" and its smaller energy consumption per candle power (a carbon filament uses 3·5 watts per candle power), tantalum has been applied to the construction of electric lamps. The figure shows a lamp which gives 24 to 27 candles at 110 volts and 0·35 amperes; the wire is 0·05 mm. in diameter and 650 mm. long; it gives a bluish white light. When heated in air, tantalum begins to oxidise, turning yellow at 400° and ultimately giving the white pentoxide; it absorbs hydrogen readily and nitrogen on heating; it does not amalgamate with mercury. When heated and thrown into water, it decomposes it. It is not attacked by acids except hydrofluoric, which attacks it slowly; aqueous alkalis do not attack it even on boiling.

Tantalum belongs to Group V. of the Periodic system, and is allied to vanadium and niobium; it occurs with niobium in tantalite, columbite, pyrochlor, and yttrotantalite. The metal is obtained by heating

sodium or potassium tantalofluoride with sodium; the powdery metal so obtained is pressed to coherent masses and heated in the electric arc in a vacuum, when the metal melts to a platinum-like regulus.



To obtain the tantalofluoride, finely powdered tantalite is fused with acid potassium sulphate, the melt extracted with water, and the insoluble part digested with ammonium sulphide; the residue is washed and boiled with dilute hydrochloric acid; the insoluble part is washed, dissolved in hydrofluoric acid, filtered, and heated to drive off silicon fluoride, and potassium fluoride added. On concentrating potassium tantalofluoride, K_2TaF_7, crystallises out first. Two oxides of tantalum are known, a tetroxide, Ta_2O_4, and a pentoxide Ta_2O_5—the latter is obtained by heating potassium tantalofluoride with concentrated sulphuric acid, extracting the potassium sulphate with water, and heating the insoluble tantalum sulphate. The chloride, $TaCl_5$, crystallises in yellow needles; melts at 211°; boils at 242°; sublimes below its melting point; it fumes in air, and water converts it into tantalic acid, $HTaO_3$.

Tanto (*Music*). Too much; as much as.

Tap (*Eng.*) (1) A cock. (2) A tool used for cutting internal or female screw threads. A FIRST TAP, ENTERING TAP, or TAPER TAP is a steel screw or external thread, with flutings or grooves (usually three in number) cut across the thread parallel to the axis of the screw in order to present a series of cutting edges; towards the point the thread is gradually removed, so that the diameter of the tool is reduced at the end till it is sufficiently small to enter a TAPPING HOLE (*q.v.*) drilled to receive it. After the tapering tap has roughed out the thread in the hole, a SECOND TAP with somewhat less taper may be passed through, and the thread is finally finished off with a parallel tap the full size of the required thread, termed a PLUG TAP. For making dies (*see* STOCKS AND DIES) a tap somewhat similar to a Plug Tap is used: this is termed a MASTER TAP, HOB, or HUB. The flutings of a master tap are narrower and more numerous than those of an ordinary tap.

—— (*Met.*) To tap a furnace is to open the TAP HOLE, an opening through which the molten metal flows.

Tape (*Build., Eng., etc.*) A measuring tape may be made either of a woven fabric or of a thin steel band; the latter is much preferable, as a woven tape stretches considerably with use, and becomes inaccurate.

Taper. A gradual slope or a diminution in diameter. Applied especially to the narrowing of a pattern, in order to enable it to be withdrawn easily from a mould. The part of a deep pattern which is uppermost in the mould, and which is withdrawn first, may be from one-eighth to a quarter of an inch wider than the lowest part.

Tapered Pipe (*Build.*) A stoneware drain pipe with one end smaller than the other.

Taper Screw Chuck (*Eng., etc.*) A chuck consisting of a small disc, in the centre of which is a coarse-threaded tapering screw, like an ordinary wood screw, by means of which a piece of wood can easily be attached to the chuck for turning.

Taper Tap (*Eng.*) The tap first used to form the thread in tapping a hole. *See* TAP.

Taper Turning (*Eng.*) Turning a conical surface. Usually effected either by setting the back centre out of the axial line of the lathe, or by using a slide rest with one of its slides set at the necessary angle to the bed of the lathe.

Tapestry. An ornamental textile fabric used for covering walls and furniture, or for hangings. The fabric is composed of coloured wools and silk, other materials, *e.g.* gold thread, being sometimes introduced. The method of manufacture is practically that of the Oriental carpet, the design being effected entirely by the weft, which is inserted by means of wooden needles or spindles termed "broaches," the whole of the operations being carried out from the back of the warp. Tapestry may be divided into two classes: (1) High Warp, in which, during manufacture, the warp is stretched vertically, with a roller or cylinder at each end; (2) Low Warp, in which the work is carried on with the warp in a horizontal position. The first method is generally employed for high class pictorial work; the second for the production of less intricate designs, though in the finished state it is difficult to distinguish the fabrics. In the fourteenth century some Flemish towns, notably Arras, were noted for their fine tapestries, hence the name "arras" eventually became synony-

mous with "tapestry." The Bayeux Tapestry (*q.v.*) is really an embroidered roll of linen. South Kensington Museum contains a very fine collection of tapestry.

Tape Worms (*Hygiene*). Parasites which affect man and food animals, chiefly under the forms of *Tæina solium*, *T. mediocanellata*, and *T. echinococcus*. *See* PARASITES.

Tap Grooving (*Eng.*) Cutting the flutings or grooves in a tap (*q.v.*) Usually performed by a rotary cutter.

Tap Hole (*Met.*) *See* TAP.

Taping (*Elect. Eng.*) Covering a conductor, etc., with tape, which forms part of the insulating or protecting covering.

Tapioca (*Foods*). A farinaceous substance prepared from the roots of the plant *Cassava*, the name given to several species of *Manihot* (*q.v.*), which grow in tropical America and elsewhere. The granules resemble those of sago, but are considerably smaller. Certain poisonous qualities of the root are removed by washing and heating the pulp.

Tappet (*Eng.*) An arm, cam, collar, or lever projecting from some movable part of a machine in such a manner that the motion of that part of the machine brings it in contact intermittently with some other part to which it communicates an intermittent motion.

—— *or* **Eccentric** (*Weaving*). A shedding motion produced in the power loom by means of mechanism termed variously cams, eccentrics, tappets, or wipers, and suitable shafts or levers which are connected with the healds or heddles. (*See* LOOM.) The motion is employed for weaving the simplest forms of plain cloth. *Cf.* DOBBY *and* JACQUARD. In the woollen trade the two chief types of tappet loom are (1) the Woodcroft, in which the shafts are both lifted and depressed positively; (2) the Yorkshire, in which the lifting motion is positive and the depressing negative. In the cotton trade the chief types are (1) box tappets; (2) sections; (3) oscillating; (4) cams. Some of these are positive and some negative in action.

Tapping (*Eng.*) Cutting an internal screw thread by means of a TAP (*q.v.*)

—— (*Met.*) Opening the tap hole (*q.v.*) of a furnace to allow molten metal to flow out.

Tapping Hole (*Eng.*) A hole in which an internal thread is to be cut. It is drilled out so that its diameter is less than that of the screw which has to fit into it by twice the depth of the thread; this leaves sufficient metal to form the internal thread, the grooves being formed by means of the thread on the tap. *See* TAP *and* TAP WRENCH.

Tap Wrench (*Eng.*) A two-handled lever or bar, used for turning a tap (*q.v.*) It usually has a medial hole which fits the squared head of a tap, different sizes being used according to the size of the tap. Some forms, however, have adjustable clamping pieces, by means of which taps of various sizes can be actuated by the same tap wrench.

Tar. A black viscid product of very mixed composition, resulting from the dry distillation of certain natural organic substances. Not very long ago tar was produced solely from wood. At the beginning of the nineteenth century, however, tar began to be made from coal, and more recently petroleum tar has been added to the list. Wood tar and gas tar are dealt with separately; but attention is directed to the general resemblance existing between the methods and results of the dry distillation of coal and that of wood. This resemblance affords an additional argument in favour of considering coal to be of vegetable origin, although the fact is proved without this assistance. In both cases there are three distinct products of the distillation—*viz.* gas and two liquids—one watery, the other dark and thickly flowing. In both the nature of the distillate, although, of course, depending upon the kind of substance distilled, is also largely influenced by the temperatures used and by the rate at which the temperatures are arrived at. Again, although there are many substances produced by coal distillation which are absent from the distillate obtained from wood and *vice versâ*, the two distillates contain many substances in common.

WOOD TAR.—This is prepared as a by-product in the manufacture of charcoal. When wood is burnt in the open air in "meilers," the tar sweats out, and is collected in receptacles placed underground near the meiler. On the other hand, when wood is charged in retorts, the tar is collected in receivers exactly as coal tar or any other distillate is collected. The wood is heated either by direct fire or by superheated steam. Both the yield and the composition of the distillate depend upon the sort of wood used and the other conditions above referred to. Coniferous wood gives more tar than others, and is used for the purpose when it ceases to yield turpentine. With slow distillation coniferous wood gives from 9 to 14 per cent., and other woods from 5 to 11 per cent. The tar separates by gravity from the weak aqueous solution containing acetic acid and spirit among other things which accompany it, as it is heavier than water, having a specific gravity averaging from 1·1 to 1·2. It happens sometimes, however, that untapped trees of certain resinous conifers are distilled into tar. In this case the turpentine, which also comes over, dissolves the tar into a liquid which is lighter than water, and therefore forms the upper instead of the lower layer. It is used as produced, or after a second distillation, for waterproofing and preserving ropes and timber. It is unaffected by water as regards its main constituents, and it contains creosote, which is a powerful antiseptic. The tar usually retains some of the crude acetic (pyroligneous) acid formed in the distillation of the wood, an amount varying from 5 to 15 per cent. according to the distillation and the sort of wood used. This is removed by neutralisation with lime, and the remaining tar will give on distillation from 5 to 15 per cent. of "light oils," from 15 to 20 per cent. of "heavy oils," and from 35 to 60 per cent. of non-volatile residue known as pitch. The pyroligneous acid is used for several purposes. For example, it serves to make impure acetates used by dyers in mordanting, but it is also rectified for the production of pure acetic acid. The methyl alcohol separated out during this process is used for denaturating or methylating spirits of wine. The light oils contain benzole and toluol, and can be used in dye manufacture. The most important constituents of the heavy oils are paraffin, creosote, and guiacol. The two last are extensively used in pharmacy, and creosote, which consists principally of carbolic and cresylic acids, is extensively employed for waterproofing timber. The residual pitch of the distillation is used as a protection against water, being painted or poured over the surface to be protected while hot and liquid. Its constitution is complicated and imperfectly known;

but it may be regarded as a mixture of heavy oils which have resisted the temperatures employed in the distillation with free carbon obtained by the charring of the less volatile distillates. The uses of paraffin are chiefly for candle making and as an insulator in electrical appliances.

COAL TAR.—The use of coal tar dates necessarily from the introduction of coal gas, and for a long time it was only obtained as a by-product of the manufacture of that gas. Large quantities are now obtained, however, from the coke ovens in which coke is prepared from coal for metallurgical purposes, when the gas is used to help heat the ovens; and still more from the gases escaping from blast furnaces, which are, of course, huge gas retorts. The present annual production of coal tar in England has been estimated at 650,000 tons from gas works, 150,000 from blast furnace gases, and 62,000 from coke ovens. Coal tar is a black, viscid liquid having a specific gravity of from 1·1 to 1·2. It sinks below the watery distillate (which is now the source of all the ammonia and ammonia salts of commerce) in the gas main, and the two liquids are drawn off separately from time to time. Like wood tar, coal tar is extraordinarily complex in its constitution. It is a mixture of certainly more than a hundred different substances. It will be gathered from what follows that it is a much more valuable commercial product than wood tar. The composition of the tar is regulated by the same circumstances as that of wood tar; but in general the substances constituting it may be classified under the following three heads: Hydrocarbons, nitrogenous bodies, and alcohols (phenol and its homologues). The most important hydrocarbons are benzole, naphthalene, anthracene, phenanthrene, and chrysene (*q.v.*) The nitrogenous bases include aniline, quinoline, and pyridine, and the most important alcohols are phenol, naphthol, and cresol. The tar is distilled in enormous stills, in some of which forty tons can be heated at one time. Disregarding the minor fractionations which are carried out in practice, the distillates may be divided into three main portions: FIRST RUNNINGS and LIGHT OILS come over up to 210° C., and form from 3 to 8 per cent. of the tar. They contain benzole and toluol. When the temperature has reached 210° the CARBOLIC OILS begin to come over. They constitute from 16 to 20 per cent. of the tar, and are replaced between 270 and 400° by the anthracene oils. The carbolic oils contain phenol (carbolic acid), cresol, and naphthalene; while of the anthracene oils, which also form from 16 to 20 per cent. of the tar, the most valuable constituent is anthracene. There is a final residue of about 50 per cent. of pitch, which has the same uses as wood pitch. The various volatile constituents are separated by fractionating separately the different distillates obtained in the first crude distillation, advantage being taken of the differences in their boiling points. The uses of the coal tar products are so well known that only a passing reference to them is required. The huge dye-making industry, which employs hundreds of thousands of persons, draws nearly all its raw materials from coal tar. Hardly less important is the manufacture of drugs, such as phenacetine, antipyrine, etc., and of photographic developers, such as metol and many others, from coal tar. Carbolic acid and cresol are well known as among the most valuable and widely used disinfectants; and lastly, it should be mentioned that some of the nitrogenous bases, such as pyrol and pyridine, are coming into use for methylating spirit, as they give a liquid which cannot be fraudulently renaturated, as is possible with ordinary methylated spirit.—A. S. J.

Targe *or* **Target** (*Arm.*) A small shield of circular form; a buckler. The term was applied generally in the seventeenth century to any form of shield used by an infantry soldier as a substitute for body armour.

—— (*Her.*) A charge representing a circular shield.

Tarsia. A kind of mosaic woodwork forming a panel; a style of decoration in vogue in Italy in the fifteenth century. The designs often comprised architectural features, foliage, and even landscapes, and were effected by means of various woods either naturally or artificially shaded.

Tartan (*Textile Manufac.*) A fabric, originally produced in the Highlands of Scotland, of a plaid or check pattern.

Tartar Emetic (*Chem.*) $\left\{\begin{array}{l} CHOHCOOSbO \\ | \\ CHOHCOOK \end{array}\right\}_2 H_2O$ or

$\left\{\begin{array}{l} CHOHCOO \\ | \\ CHOHCOO \end{array}\!\!\!>Sb\,.\,OK\right\}_2 H_2O$ (Potassium antimonyl tartrate). Colourless rhombic octahedra, which effloresce on exposure to air; soluble in water (1 part in 15 parts at 15°). Poisonous, but in small doses it acts as a sudorific; in larger doses as an emetic. Its solution gives a precipitate with tannic acid; it also decolorises a solution of iodine (basis of estimation). It is prepared by boiling 4 parts antimony trioxide, 5 parts cream of tartar, and 50 parts water, filtering if necessary, and allowing to stand till crystallisation occurs.

Tartaric Acid (*Chem.*) $\begin{array}{l} CHOHCOOH \\ | \\ CHOHCOOH \end{array}$ (Dioxysuccinic acid.) As this compound contains two asymmetric carbon atoms having the same radicals attached to each, it can occur in a dextrorotatory form, in a lævorotatory form, and in two inactive forms, one due to internal compensation (mesotartaric acid), and the other due to a combination of equal quantities of the two active forms (racemic acid). *See* STEREOISOMERISM. ***Dextrotartaric acid*** is the ordinary tartaric acid. Colourless monoclinic prisms; melts at 153°, or 167°-170° if rapidly heated; very soluble in water (138 in 100 parts at 15°); soluble in alcohol (20·4 parts in 100 at 15°); the aqueous solution is dextrorotatory, the specific rotation varying with the concentration. When heated with water (10 parts acid to 1 part water), it is changed to a mixture of racemic acid and mesotartaric acid; at 165° little of the former and much of the latter, while at 175° the reverse is the case. A solution of tartaric acid prevents the precipitation of hydroxides from salts of copper, iron, aluminium, and many other metals by alkalis. On careful oxidation it yields dihydroxytartaric acid (*q.v.*); powerful oxidising agents give carbon dioxide and water. When tartaric acid is dry distilled, it yields among other products pyrotartaric acid (*q.v.*) and pyruvic acid (*q.v.*) On reduction with hydriodic acid it yields first malic acid, then succinic acid. Ammoniacal silver nitrate oxidises tartaric acid (its salts), on warming, to carbon dioxide and oxalic acid. *See* SILVER. Tartaric acid occurs chiefly as acid potassium tartrate (cream of tartar), especially in grape juice; on fermentation the tartrate is deposited after a time, and the crude deposit is

called argol, or, after recrystallisation, tartar; when crystallised till pure the product is called CREAM OF TARTAR. This salt also occurs in many common fruits and vegetables, such as cucumbers, berries of mountain ash, mulberries, sorrel. The acid also occurs in the same things as calcium salt, but in much smaller amount. On the large scale tartaric acid is obtained from argol by adding water and boiling by steam, then adding powdered chalk:

$$2KH\bar{T} + CaCO_3 = Ca\bar{T} + K_2\bar{T} + H_2O + CO_2.$$

The calcium tartrate is filtered off, and the solution of potassium tartrate precipitated by calcium chloride (or gypsum):

$$K_2\bar{T} + CaCl_2 = Ca\bar{T} + 2KCl.$$

The whole of the calcium tartrate is washed and decomposed by warm dilute sulphuric acid, the calcium sulphate filtered off and washed, and the filtrate concentrated in steam-heated leaden pans to crystallisation. The coloured crystals are dissolved in hot water, decolorised by animal charcoal, and again crystallised with addition of a little sulphuric acid. For medicinal purposes the product is recrystallised. Synthetically dextrotartaric acid is obtained by the resolution of racemic acid into its components; the racemic acid is made into sodium ammonium racemate, and the solution of this salt slowly crystallised. Crystals with right and left hand hemihedral faces separate, which can be separated by hand. On making each into the lead salt and decomposing the latter by sulphuretted hydrogen, the dextrohemihedral crystals give dextrotartaric acid and the others lævotartaric acid. This was the first instance of the resolution of an optically inactive substance into its active components, and the resolution was effected (1847) by Pasteur at the age of twenty-five. Racemic acid can also be resolved by combining it with a number of active alkaloids—*e.g.* with quinine, in which case the salt of dextrotartaric acid crystallises first. *Lævotartaric acid* is similar to dextrotartaric acid, except that the crystalline form is the mirror image of that of the dextro acid, and its solution is lævorotatory. It is obtained, as described above, from racemic acid: and when a solution of racemic acid is fermented with penicillium glaucum, the dextro acid is destroyed, while the lævo acid remains. RACEMIC ACID forms triclinic prisms containing one molecular proportion of water of crystallisation, which it loses at 100° to 110°; melts at 205°; less soluble in water than tartaric acid; its solution is optically inactive; chemically it behaves like tartaric acid, but on reduction with hydriodic acid it gives inactive malic acid. It is formed by the union of equal quantities of the dextro and lævo acids with evolution of heat, and from tartaric acid as before mentioned. Synthetically it can be obtained from fumaric acid by oxidation with potassium permanganate: along with mesotartaric acid, from the silver salt of dibromsuccinic acid by boiling it with silver oxide and water,

$$\begin{array}{l}CHBrCOOAg\\ |\\ CHBrCOOAg\end{array} + 2AgOH = \begin{array}{l}CHOHCOOAg\\ |\\ CHOHCOOAg\end{array} + 2AgBr,$$

and also along with mesotartaric acid from glyoxal by the series of reactions indicated in the scheme:

$$\begin{array}{l}CHO\\ |\\ CHO\end{array} \xrightarrow[HCN]{} \begin{array}{l}CH<^{OH}_{CN}\\ |\\ CH<^{CN}_{OH}\end{array} \xrightarrow[H_2O]{} \begin{array}{l}CH.OH.COOH\\ |\\ CH.OH.COOH.\end{array}$$

MESOTARTARIC ACID. This compound is inactive by internal compensation. *See* STEREOISOMERISM. Crystallises in rhombic tables with one molecular proportion of water of crystallisation; melts at 140°; soluble in water (125 parts in 100 parts at 15°); obtained from dextrotartaric acid as before mentioned, and separated by converting the product into the acid potassium salts, of which the mesotartaric is very soluble in water, while the dextrotartrate is very sparingly soluble, also from the mixtures of mesotartaric and racemic acids by conversion to the calcium salts, of which calcium mesotartrate is the more soluble, also from maleic acid by oxidation with potassium permanganate. TARTRATES. *Acid potassium tartrate*, or cream of tartar, $\begin{array}{l}CHOHCOOH\\ |\\ CHOHCOOK\end{array}$ crystallises in rhombic prisms; sparingly soluble in water (1 part in 200 parts at 15°), less soluble in alcohol. Can be prepared from tartaric by dividing a given solution of the acid into two equal parts, exactly neutralising one part with caustic potash, and then adding the other part; on the large scale, as before mentioned. It is used in making black flux, in dyeing, and in medicine. *Sodium potassium tartrate* (Seignette's salt, or Rochelle salt); rhombic prisms; soluble in water; obtained by neutralising cream of tartar with sodium carbonate. Used in silvering glass (*see* SILVER), and in medicine. *Calcium tartrate*, $\begin{array}{l}CHOHCOO\\ |\\ CHOHCOO\end{array}\!\!>Ca$, crystallises in rhombic prisms containing four molecular proportions of water when calcium chloride is added to a neutral solution of a tartrate; very sparingly soluble in water (1 part $Ca\bar{T},4H_2O$ in 6,265 parts water at 15°); soluble in alkaline tartrate solution, and in caustic soda or potash. *Potassium antimony tartrate*. *See* TARTAR EMETIC.

Tartrates (*Chem.*) Salts of TARTARIC ACID (*q.v.*)

Tartrazine (*Chem.*, *Dyeing*). *See* DIHYDROXYTARTARIC ACID.

Tar Well (*Gas Manufac.*) *See* GAS MANUFACTURE.

Tassets (*Arm.*) A pair of metal appendages, often jointed and flexible, which hung from the cuirass or corselet to protect the thighs in front. Worn during the fifteenth, sixteenth, and seventeenth centuries.

Tasto Solo (*Music*). Implies that the notes are to be played without accompanying harmonies.

Taurine (*Chem.*) $\begin{array}{l}CH_2NH_2\\ |\\ CH_2SO_2OH\end{array}$ (Amidoisethionic acid). Colourless monoclinic prisms; melts with decomposition about 240°; soluble in water, insoluble in alcohol. It behaves as a weak acid. Nitrous acid converts it into isethionic acid $\begin{array}{l}CH_2OH\\ |\\ CH_2SO_2OH.\end{array}$ Taurine occurs free in bile, but chiefly in combination with cholalic acid as taurocholic acid. The latter yields taurine on hydrolysis.

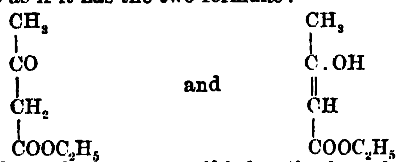
$$C_{26}H_{45}NO_7S + H_2O = \begin{array}{l}CH_2NH_2\\ |\\ CH_2SO_2OH\end{array} + C_{24}H_{40}O_5.$$

Taurine can be obtained from ox-bile by adding hydrochloric acid, filtering, and concentrating when a resinous mass separates; the aqueous solution is

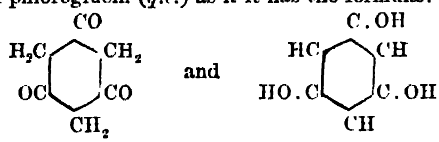
poured off, further concentrated, filtered, and the taurine precipitated by alcohol; it is recrystallised from water.

Taurocholic Acid (*Chem.*) $C_{26}H_{45}NO_7S$. Needles; very soluble in water and in alcohol, less soluble in ether; when boiled with water it is hydrolysed. *See* TAURINE. The solution is dextrorotatory. It occurs as the sodium salt in bile; to obtain it bile is precipitated with lead acetate, which separates glycocholic acid, filtered, and the filtrate precipitated by basic lead acetate. The lead taurocholate thus precipitated is decomposed by sulphuretted hydrogen.

Tautomerism (*Chem.*) Many substances are known which react as if they possess more than one formula. For example, ethyl acetoacetate (*q.v.*) reacts as if it has the two formulæ:

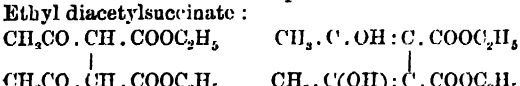


and phloroglucin (*q.v.*) as if it has the formulæ:



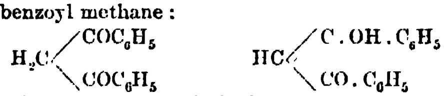
while 1-phenyl-3-methyl-5-pyrazolone (*see* PYRAZOLE AND ITS DERIVATIVES) can react as if it has three formulæ. To this phenomenon many names have been given, such as Tautomerism, Pseudomerism, Desmotrophy. Of these, perhaps the commonest is the first one. In the above examples, although the substances react as if they have more than one formula, they are only known in one form; but in some cases the so-called tautomers are known in more than one form. Examples of such are:

Ethyl diacetylsuccinate:

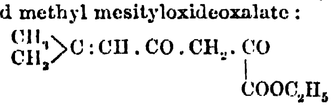


Keto form (two solid forms). M.Ps. 68° and 88°. Enol form (liquid).

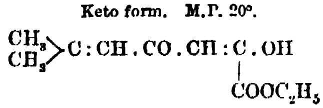
Debenzoyl methane:



Ethyl and methyl mesityloxideoxalate:

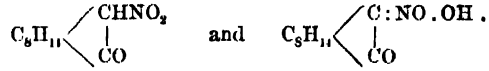


Keto form. M.P. 20°.

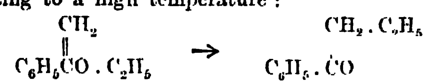


Enol form. M.P. 59°—60°.

We will illustrate the relations between the two forms a little more fully in the last case. The enol form goes over into the keto form on prolonged heating on the water bath; the keto form passes in part into the enol form on prolonged heating at 130°; the enol form shows the higher refractive and dispersive power for light. In this case, on solution the enol appears to pass entirely into the ketol, but the solvent exercises a great influence on the speed, ionising solvents bringing about the change far more rapidly than non-ionising—thus in chloroform the change is very slow, in benzene and carbon disulphide it is slow, but in methyl and ethyl alcohol the change is rapid. Thus it must be assumed that in these cases ionisation occurs. With some tautomers equilibrium between the two forms occurs on solution; this is the case with nitrocamphor, which is a solid, and only known in one form in the solid state, but, as the change of rotatory power on solution shows, it must be present in solution in two forms—the normal form and pseudo form:



The determination of which of the possible formulæ of a tautomeric substance is to be assigned to it is carried out by physical methods; examples of such determinations are given under MOLECULAR MAGNETIC ROTATION, MOLECULAR REFRACTIVE POWER, SPECTRUM ANALYSIS. It will be seen from the foregoing that tautomerism is nothing more than ordinary isomerism between substances which can pass somewhat readily into each other; that is to say, no very sharp line of demarkation exists between tautomerism and ordinary isomerism. Most tautomeric compounds contain a mobile hydrogen atom. When the mobile group is complex, the change of one tautomer into the other becomes more difficult to effect; this isoacetophenone ethyl ether is only changed into phenylpropyl ketone on prolonged heating to a high temperature:



When the two tautomeric forms can exist in equilibrium with each other, the phenomenon is called by some chemists "dynamic isomerism." A method of determining the point of equilibrium in such cases has been devised by Lowry; it depends on the measurement of the solubility of one of the isomers, or better, when the substance is optically active, of the change in rotation which occurs on solution, for the two forms will not have the same specific rotatory power. Suppose a tautomeric substance A to be known in one form only; let it be dissolved in a solvent in which the change into the form B is not quick—say it takes days. Determine its solubility at once by thoroughly shaking an excess of A with the solvent until the latter is saturated, and then finding how much is dissolved in a given weight of the solvent. Now set aside a part of the saturated solution in contact with excess of A; as A transforms into B, more of A will go into solution, and this will continue until equilibrium is established between A and B in solution and between the solid and liquid phases of A. Determine the solubility under the new conditions, and it is clear that if α is the first solubility and β the second, we have equilibrium between α of A and $(\beta - \alpha)$ of B. A similar argument holds for the change in specific rotation.

Tawing (*Leather Manufac.*) The process of dressing skins for glove leather by means of alum, salt, flour, and egg.

Tazza. A large shallow ornamental cup or bowl, mounted on a foot and generally having two handles.

T-Bolts *or* **Tee Bolts** (*Eng.*) Bolts with large heads (usually rectangular), forming a T. They are used in the tee slots (*q.v.*) of machine tables.

Te (*Chem.*) The symbol for Tellurium (*q.v.*)

Tea (*Foods*). Tea consists of the dried leaves of a shrub, *Thea sinensis*, grown in China, Japan, India, and Ceylon. Green tea differs from black solely in the method of preparation, the former being dried over wood fires when fresh, the latter being dried slowly over charcoal fires after lying in heaps (withering) for about twelve hours. Tea contains albumin, extractives (about 15 per cent.), dextrine, mineral salts, tannin (about 13 per cent.), oil, and an alkaloid known as thein (about 3 per cent.) Tea should be made with boiling water and not allowed to stand longer than five minutes, otherwise the quantity of tannin extracted renders the infusion astringent and unwholesome. If soft water be used a less quantity of tea is required. As a beverage tea is valuable as a nervous stimulant; but the abuse of it leads to a weakened digestion, constipation, and sometimes nervous depression. *See* FOODS.

Teak. *See* WOODS.

Teazing (*Woollen Manufac.*) The operation of mixing the wool prior to carding (*q.v.*)

Technique (*Arts*). The mastery of detail and the qualities of hand and eye that result in technical and manipulative skill.

Tedge (*Foundry*). A GATE or RUNNER (*q.v.*)

Tee Bolt, etc. *See* T-BOLT.

Teeming (*Met.*) Pouring out molten metal. Used especially by the steel makers in the North of England.

Tee Slots (*Eng.*) Slots formed on the surface of the table of a planing machine or slotting machine, etc., in order to hold the heads of Tee Bolts: the cross-section of the slot is in the shape of a T, and of such a size that the bolt can be inserted at one end, and then moved along it to any point at which an object has to be bolted to the table.

Telamones (*Architect.*) *See* ATLANTES.

Telegraph and Telegraphy. The simplest form of telegraphic apparatus consists in principle of a galvanometer (the RECEIVING INSTRUMENT or RECEIVER) connected by an insulated wire (the LINE) to a battery and to a transmitting key, or TAPPER, placed at a distant station; the circuit is usually completed through the earth, to which both ends of the system are connected. By means of the transmitting key an operator can cause a current to flow in either direction at will, thus producing a deflection of the receiving needle either to the right or the left. The instrument can thus transmit two distinct signals, which may be combined together in any manner desired, *e.g.* to produce an alphabet and other signals desired; the combination of signals in general use is that known as the Morse Alphabet or Morse Code.

The two signs used are generally represented as a dot and a dash, and the alphabet is formed as follows:

A • —	J • — — —	S • • •
B — • • •	K — • —	T —
C — • — •	L • — • •	U • • —
D — • •	M — —	V • • • —
E •	N — •	W • — —
F • • — •	O — — —	X — • • —
G — — •	P • — — •	Y — • — —
H • • • •	Q — — • —	Z — — • •
I • •	R • — •	

Other combinations of dots and dashes are used to indicate figures, and also certain other signs and abbreviations.

The single needle instrument may be replaced by one with two needles; or an instrument may be used in which a sound is produced by the motion of an armature attracted by an electro-magnet. By employing an instrument which can give two distinct sounds, or by using long or short intervals between successive sounds, the two signals necessary for the MORSE CODE can be obtained. The receiving operator reads the message by ear alone, and can write it down as it is received. When the line is of great length, and the transmitted currents are feeble, either a very sensitive receiving instrument is used, or a relay (*q.v.*) is fitted to the receiving instrument, which is then actuated by a local battery, the feeble current in the line being utilised to actuate the relay.

The above instruments have the two great disadvantages that no permanent record of the messages can be obtained, and that the speed of transmitting is very limited. Both these defects are overcome in printing or writing instruments. In these the current actuates an instrument which can make a mark upon a long strip of paper drawn through the receiver by mechanism. To obtain the two distinct signals; the marks may be made short and long ("dot and dash") as in the Morse Printing Telegraph, or a continuous line may be produced, which remains straight so long as no current is sent through the receiver, but is bent into a sinuous form if the writing device be deflected to one side or the other by the action of the current. The Kelvin Siphon Recorder is of the latter type, the line being drawn by ink flowing from the end of a fine tube, bent into a siphon, and dipping into a reservoir of ink. The deflection of the siphon is produced by a coil suspended between the poles of a magnet, the passage of a current through the coil causing it to turn, as in the D'Arsonval Galvanometer. Increased speed is attained by a mechanical method of transmission. A strip of paper is perforated with holes arranged to correspond with the dots and dashes of the Morse code, and the strip is then drawn through a transmitting instrument so constructed that a hole in a particular position causes the circuit to be completed and a current sent through the line. The strips are perforated by a machine worked by hand, but a long message may be prepared by employing a number of operators simultaneously, the strips being afterwards passed through the transmitter in succession. By this means the speed of transmission may be increased ten-fold or even more, a matter of great importance when a number of lengthy messages have to be sent over a given system. In a recently invented form of writing telegraph the record is obtained by the action of a beam of light on a strip of sensitised paper, which is afterwards developed and fixed; the deflection of the beam is produced by the movement of a very small mirror, such as is used in reflecting galvanometers. The moving parts are very light, and the necessary motion very small, so that the mirror responds very rapidly to a very small current. With this telegraph, developed by Virak and Pollak, the extraordinary speed of 1,000 words per minute is said to have been attained. Printing telegraphs have also been devised to record the message in ordinary characters; they may be roughly described as electrically worked typewriting machines, in which a keyboard at one station actuates printing mechanism at another by means of an electric current.

LAND LINES, or the wires used for ordinary telegraphy on land, are usually of bare iron wire, having a resistance of about 16 ohms per mile; they are attached to insulators of earthenware, carried on the cross bars on the poles. But the use of underground wires is increasing, owing to frequency of breakdowns in aerial wires through storms and other causes. Such wires are necessarily coated with insulating substances, and further covered with some material to protect them from the action of water. SUBMARINE CABLES require still further protection, and are usually surrounded by a sheath of wires, covered with hemp and guttapercha.

The testing of the wires forms a very important branch of the telegraphist's work, and breakages, contact between two lines, a complete or a partial connection to earth, can all be detected and the position of the fault found by an operator perhaps many miles away. Many of the methods employed depend on the accurate measurement of resistances, the form of Wheatstone's Bridge (*q.v.*) termed the Post Office Box being largely used in this connection. The electrical capacity of a system is also in certain cases a guide to the detection of a fault.

DUPLEX telegraphy consists in sending messages along a single wire in both directions at the same time; in the commonest case this is effected by connecting the instruments and the line to the earth by suitably adjusted resistances, forming a combination of conductors resembling that of a Wheatstone Bridge. In DIPLEX working two messages may be sent simultaneously in the same direction, special instruments being used which only act when the current flows through them in one direction. In QUADRUPLEX telegraphy, two messages may be sent each way simultaneously, a combination of the DUPLEX and DIPLEX methods being employed.

Telegraphy, Wireless (*Elect. Eng.*) *See* WIRELESS TELEGRAPHY.

Teleiconograph. An instrument consisting of a combination of the telescope and the camera lucida (*q.v.*), invented by M. Révoil. The camera lucida is attached to the eyepiece of the telescope in such a manner that an image of objects coming within the field of view appear to the observer to be projected on a sheet of paper placed below the eyepiece so that the outline can easily be sketched. The scale of the drawing depends on the distance the paper is placed from the eyepiece.

Telemeter (*Surveying*). An American term for the stadia (*q.v.*)

Telephone. One of the most typical forms of telephone is that of Bell. This contains a thin circular plate or diaphragm of iron, supported at its circumference; a bar magnet is placed with its axis at right angles to the diaphragm, and one pole placed opposite and close to the centre. A coil of fine wire surrounds the magnet, being placed close to the same pole. When sound waves fall upon the diaphragm the latter is caused to vibrate, and as the iron approaches or recedes from the pole of the magnet, induced currents are set up in the coil of wire. If the latter be connected by wires to the coil of a similar instrument or RECEIVER placed at a distance, the induced currents, in flowing through the second coil, will set up vibrations in the diaphragm of the receiver, which correspond very closely to those of the first or "transmitting" diaphragm, and the original sounds will be closely reproduced. This instrument is now used chiefly as a receiver, and in many cases the original form is very closely adhered to. Its use as a transmitter was, however, abandoned at an early date, and a different form of instrument substituted for this purpose, by which the effects were very greatly improved. Modern transmitters are based upon the principle of the MICROPHONE (*q.v.*) The original microphone of Hughes was a light pointed rod of carbon, supported loosely in a vertical position between two carbon blocks; the instrument was connected in series with a battery and a telephone receiver, and the current entered the microphone by one block, passing through the carbon rod and the two loose contacts, and left by the other block. No sound is heard in the receiver so long as the current is steady; but a very minute movement of the carbon rod causes a variation of the resistance of the circuit, and a corresponding alteration of the current, which produces a movement of the diaphragm of the receiver, and consequently a sound. The vibrations of the receiving diaphragm are much stronger than the original ones, and sounds as minute as those produced by a fly walking over the base board of the microphone, are distinctly heard on the telephone. In modern transmitters, the sound impinges on a metal diaphragm, behind which lie loose carbon contacts, often in the form of small grains; the electrical connections follow the same principle as in the original instrument.

The action may be improved in long lines by the insertion of a small induction coil in the circuit. The transmitter and battery are included in the primary coil, and the secondary coil, which has a much larger number of turns of wire, is connected in series with the transmitting wires or "telephone line," and with the receiver. By this means a much higher voltage, and consequently a stronger current, is obtained in the receiving circuit than would be the case if the coil were not used.

A simple form of telephone "set" consists of receiving and transmitting instruments, a call-bell, and a bell-push by which the bell at the receiving end of the line can be rung: the induction coil and battery may also be included. The receiver when not in use is hung from a lever forming part of a switch, which connects the line to the call bell, so that the latter can be rung to attract attention; on removing the receiver from its support, the lever rises and operates the switch in such a way that the line is disconnected from the bell, and connected to the receiver itself, so that a message spoken into the transmitter at the other end can now be heard.

Inter-communication between different subscribers is effected by means of an EXCHANGE; a subscriber first "calls up," or gets into communication with, an operator at the exchange. The signal necessary to attract the operator's attention is either given by means of a bell, or the mere act of removing the receiver from its support may automatically supply the signal at the exchange, either by actuating a bell or lighting up a small glow lamp; the operator then connects up the first subscriber's instrument to that of the second subscriber whose number is quoted, by means of a switch board to which the necessary wires are attached. The arrangements of the wires and switch boards are very ingenious, but too complex for a brief description.

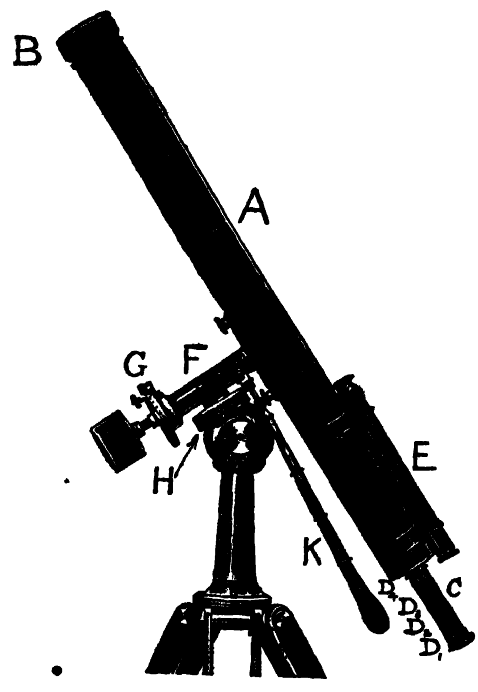
Telescope. An optical instrument by which an image of a distant object is produced, this image being viewed through a magnifying eyepiece. Telescopes may be divided into two classes, according to the means employed to produce the image. In Class 1, REFRACTING TELESCOPES, the image is pro-

duced by a lens termed the OBJECT GLASS or OBJECTIVE; in Class 2, REFLECTING TELESCOPES, the image is produced by a concave mirror of large radius, termed a SPECULUM.

(1) The object glass of a refracting telescope is an achromatic lens of long focus, which produces a real, inverted, and diminished image of the object observed. In the ASTRONOMICAL TELESCOPE this image is viewed through a lens or system of lenses acting as a simple magnifying glass, which produces a vertical, magnified, and inverted image; the inversion is, however, of no moment in astronomical work. A TERRESTRIAL TELESCOPE possesses an erecting eyepiece, usually consisting of four similar planoconvex lenses, separated by distances depending on their varying foci. GALILEO'S TELESCOPE, which forms the optical system of a modern OPERA GLASS, possesses a concave eye lens, which is placed between the object glass and the image produced by the latter. By this means an erect and magnified image is produced.

(2) Reflecting telescopes possess several distinct advantages, especially for astronomical work. They can be made of much greater aperture than refracting telescopes; chromatic aberration is entirely absent, and spherical aberration is avoided by making the speculum parabolic instead of spherical in form. The mirror may be constructed of glass, ground to shape and silvered; or of speculum metal (an alloy of copper and tin), which is capable of receiving a high polish on its surface. Reflectors differ in the method employed for viewing the image. In HERSCHEL'S TELESCOPE the axis of the mirror is inclined so as to throw the image to the side of the tube, the eyepiece being suitably placed to receive the image. In NEWTON'S TELESCOPE a small plane mirror is placed inside the tube, so as to receive the rays after reflection from the speculum, and reflect them again towards the eyepiece, which is placed at the side of the telescope and directed towards the plane mirror. In GREGORY'S and CASSEGRAIN'S TELESCOPES there is a small curved mirror placed axially inside the telescope tube. This receives the rays after reflection from the speculum, and reflects them back through a central aperture in the speculum; the eyepiece is placed so as to receive the rays through this aperture.

MOUNTING OF TELESCOPES.—Terrestrial telescopes require nothing more than a tripod stand which supports the telescope at a convenient height and enables it to be turned in any required direction by means of a suitable joint. Astronomical telescopes have much more elaborate forms of mounting, depending on the special purpose for which the instrument is required. The TRANSIT CIRCLE consists of a telescope mounted on a horizontal axis pointing due east and west and carrying a vertical graduated circle; the telescope therefore always lies in the meridian. For observations of bodies not on the meridian, and for continuous observations, other forms of mount are necessary. The ALTAZIMUTH instrument has two axes, one vertical (the PRIMARY AXIS), the other (or SECONDARY AXIS) being horizontal, and carried by the former. Each axis carries a graduated circle by which it can be brought into any position, or the angle through which it has been turned read off. An EQUATORIAL instrument has also two axes, the secondary being horizontal, but the primary one is inclined so as to point in the direction of the pole. This axis carries a graduated circle termed the HOUR CIRCLE, while the horizontal axis carries what is termed the DECLINATION CIRCLE. The figure represents a small portable Equatorial by Dollond; the object glass is of 3 in. aperture and 3 ft. 6 in. focal length.



A is the body or tube of the telescope; the object glass is at B; C is the eyepiece (a terrestrial eyepiece is shown in the figure, the four lenses being placed at D_1, D_2, D_3, D_4). E is the FINDER (*q.v.*) The primary axis is at F, inclined so as to point in the direction of the pole. The graduated circles are shown at G and H. The telescope is turned while a star is being observed by means of the handle K, so that the object always remains in the field of view.

Various accessories are used with astronomical telescopes, such as a FINDER (*q.v.*), VERNIERS, and READING MICROSCOPES for determining the exact angular position of the instrument by reading the graduated circles; TANGENT SCREWS for effecting small or gradual movements of these circles; CROSS WIRES in the eyepieces; some arrangements for illuminating the wires; and many other devices. Devices are also used for photographing celestial bodies, and for observing their spectra, but these do not form part of the telescope proper.

Telescopic Pipes (*Eng., etc.*) Pipes which slide into one another at the joints, like the tube of a pocket nautical telescope, so as to admit of a certain amount of lengthening or shortening. They are often used in pumping water from coffer dams, mine shafts, etc.

Telescopic Shaft (*Eng.*) A shaft constructed in a similar manner to a telescopic pipe to allow of longitudinal extension.

Telescopic Stars (*Astron.*) Stars that are invisible to the naked eye, and require a telescope to observe them. *Cf.* STAR MAGNITUDES.

Telespectroscope (*Astron.*) A combination of telescope and spectroscope for analysing the light of the celestial bodies.

Tell Tale (*Eng.*) An indicator used to show when a certain number of revolutions has been made by a machine, *e.g.* a WINDING ENGINE (*q.v.*); also similar automatic devices used in various machines to indicate the completion of a certain series of movements.

—— (*Music*). In organs the weight suspended from the bellows, which falls and rises as the reservoir fills and empties. One is generally in view of the organist and another in view of the blower, when blown by manual labour.

Telluric Bismuth (*Min.*) Telluride of bismuth; sulphur and selenium are also present in some cases. Hexagonal system. Colour pale grey. Found in Cumberland, Norway, Sweden, Hungary, United States, etc.

Tellurium (*Chem.*) Te. Atomic weight, 127·6. A lustrous white metal (or metalloid) belonging to Group VI. of the Periodic system; melts at 452°; boils at 478° in the vacuum of the kathode light; it can be distilled in a current of hydrogen, and may be purified in this way; crystallises in rhombohedra. Its vapour density corresponds to the formula Te_2. Tellurium burns with a blue flame when heated in air to the dioxide; it is soluble in a concentrated solution of caustic potash, forming a red solution which contains potassium telluride and potassium tellurite; nitric acid oxidises it to tellurous acid. Tellurium occurs free, and as graphic tellurium (Ag . Au) Te_2 (*q.v.*), as nagyagite $(Au . Pb)_3(Te . S . Sb)_3$ (*q.v.*), as silver telluride (Ag_2Te), and as bismuth telluride (Bi_2Te_3). It can be obtained by boiling the ore with concentrated sulphuric acid, diluting the solution, and adding hydrochloric acid; gold and silver are thus separated, and on passing sulphur dioxide into the clear solution tellurium is precipitated. For a purer product the whole operation is repeated; it may be further purified as indicated above. When precipitated from its solution by sulphur dioxide, the tellurium is in an amorphous condition. Radioactive tellurium is the name given to the deposit formed when bismuth is immersed in a solution which contains polonium. *See* RADIUM. This deposit consists chiefly of tellurium, and is strongly radioactive, but the activity is not due to tellurium, for the latter can be precipitated from the active solution in an inactive state. TELLURIDES. Telluretted hydrogen, H_2Te, is a colourless gas; boils at 0°; melts at ·48°; it has an offensive odour like sulphuretted hydrogen, and is soluble in water. It is very readily decomposed; light decomposes it, and it is partly decomposed on heating $TeH_2 \rightleftarrows Te + H_2$; it is also decomposed on contact with moist air. Telluretted hydrogen precipitates tellurides from salt solutions like sulphuretted hydrogen precipitates sulphides. The gas is obtained, mixed with hydrogen, by the action of a dilute acid on magnesium or zinc telluride; or in nearly pure condition by electrolysis of 50 per cent. sulphuric acid at −15° to −20°, using tellurium as kathode. Metallic tellurides are obtained by heating the corresponding elements together; the alkaline tellurides can also be obtained by passing telluretted hydrogen into a solution of the alkaline hydroxide. CHLORIDES. The dichloride $TeCl_2$ is a black solid which melts at 175° and boils at 327°, giving a vapour which has a characteristic absorption spectrum; it is decomposed by water: $2TeCl_2 + 3H_2O = Te + H_2TeO_3 + 4HCl$. It is formed by heating tellurium in chlorine, boiling the product with more tellurium, and distilling. The tetrachloride, $TeCl_4$, is a white crystalline solid; melts at 224°, and boils at 380°; it is deliquescent, and decomposed by water, giving an oxychloride and tellurous acid in the cold, the latter alone on boiling. It is prepared by heating tellurium in excess of dry chlorine. OXIDES. Tellurium dioxide, TeO_2, is a white crystalline solid, practically insoluble in water; it dissolves in caustic soda or caustic potash, forming tellurites Ne_2TeO_3 and K_2TeO_3; it is formed by burning tellurium or by dissolving it in nitric acid and crystallising above 20°. Tellurium trioxide, TeO_3, is an orange yellow crystalline solid; when strongly heated it gives the dioxide; water does not act on it. Boiling concentrated caustic potash gives potassium tellurate; boiling hydrochloric acid gives telluric acid and chlorine. It is prepared by heating telluric acid. ACIDS. Tellurous acid, H_2TeO_3, is a white amorphous solid, sparingly soluble in water, more soluble in acids; on heating, it readily yields the dioxide; it is a feeble acid, and dissolves in alkalis forming tellurites; potassium permanganate oxidises it to telluric acid. Tellurous acid is obtained by dissolving tellurium in nitric acid and immediately adding much water when the acid is precipitated. Telluric acid, H_6TeO_6, crystallises in white monoclinic prisms; soluble in water; it is a feeble acid; it dissolves in alkalis forming tellurites; it is reduced to tellurium by sulphur dioxide and many other reducing agents. It is prepared by dissolving tellurium in a mixture of nitric and chromic acids, crystallising the solution, washing the crystals with nitric acid and dissolving them in water, reprecipitating with nitric acid, and finally crystallising from water. SALTS. No well-defined normal salts in which tellurium acts as a metallic radical are known, so that tellurium has more of the characteristic reactions of a non-metal than a metal. Tellurites (*see* above) are known, and tellurates. Potassium tellurate, $K_2H_4TeO_6 3H_2O$, may be prepared by fusing the dioxide with caustic potash and potassium chlorate; on adding barium chloride to its solution, barium tellurate, $BaH_4TeO_6 . H_2O$, is precipitated. This barium salt is far more soluble in water than barium sulphate.

Tellurium (*Min.*) The metal has been found native, but is very rare; it usually occurs in combination as a telluride.

Temper (*Eng.*) The hardness, elasticity, and other conditions produced in steel by certain operations of heating and cooling. *See* TEMPERING.

Temperament (*Sound*). A modification of the pitch of the notes forming the scale, which enables notes belonging to one key to be used as part of the scale of another key. Consider the succession of notes forming the natural scale, or, as it is termed, a scale with JUST INTONATION: then taking the frequency of the tonic or key note as unity, the frequencies of the remaining notes are as follows:

C	D	E	F	G	A	B	C′
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2

Taking these notes in pairs it is found that the intervals, or the ratios of the frequencies of two successive notes, are not constant, but that there are three different intervals or ratios; thus the interval between the first two notes is $\frac{9}{8}$, between the second two $\frac{10}{9}$, and between the third two, $\frac{16}{15}$. The complete scale therefore contains the following intervals:

$$C \underbrace{\ \ }_{\frac{9}{8}} D \underbrace{\ \ }_{\frac{10}{9}} E \underbrace{\ \ }_{\frac{16}{15}} F \underbrace{\ \ }_{\frac{9}{8}} G \underbrace{\ \ }_{\frac{10}{9}} A \underbrace{\ \ }_{\frac{9}{8}} B \underbrace{\ \ }_{\frac{16}{15}} C'$$

The interval $\frac{9}{8}$ is termed in Acoustics a MAJOR TONE, $\frac{10}{9}$ a MINOR TONE, and $\frac{16}{15}$ a LIMMA. The major and minor tones are very nearly equal; the ratio between

them is $\frac{9}{8} \div \frac{10}{9}$ or $\frac{81}{80}$; this interval is termed a COMMA. Suppose we take a scale in which C has a frequency of 270; the other notes will then have the following frequencies:

$$\begin{array}{ll} C' & 540 \\ & \quad \tfrac{16}{15} = \text{limma} \\ B & 506\tfrac{1}{4} \\ & \quad \tfrac{9}{8} = \text{major tone} \\ A & 450 \\ & \quad \tfrac{10}{9} = \text{minor tone} \\ G & 405 \\ & \quad \tfrac{9}{8} = \text{major tone} \\ F & 360 \\ & \quad \tfrac{16}{15} = \text{limma} \\ E & 337\tfrac{1}{2} \\ & \quad \tfrac{10}{9} = \text{minor tone} \\ D & 303\tfrac{3}{4} \\ & \quad \tfrac{9}{8} = \text{major tone} \\ C & 270 \end{array}$$

This scale will be perfectly correct so long as we keep to the key of C; but if we attempt to change the key, *i.e.* to take any other note than C as the key note, we shall meet with certain difficulties. Suppose D be taken as the key note; the first interval will be a minor tone, instead of a major tone, while the next interval will be a limma, when it ought to be a minor tone, an interval nearly twice as great. The latter difficulty is met by introducing a new note between F and G, which we term "F sharp" (F♯). There exists, however, no practical method by which the first difficulty can be surmounted. A compromise is therefore effected by which the relative frequencies of the notes are so adjusted that they may be utilised in the scale of other keys with equal, or approximately equal, accuracy; this compromise is termed Temperament. There are many possible temperaments, which it is not possible to discuss here (*see* A. J. Ellis, "Proceedings of the Royal Society," vol. xxiii. pp. 3-31), but the most important is that known as EQUAL TEMPERAMENT. In this, one interval, *viz.* the octave, is kept absolutely correct and the remaining notes are sharpened or flattened, so that the major and minor tones are equalised, and each of them is made equal to two limmas or "semi-tones." There are thus twelve semi-tones in the octave, and if these be absolutely equal, any one of them may be taken as the key note, and all the scales so produced will be exactly similar. The following comparison shows the ratios of the frequencies of the notes in an equally tempered scale, the correct intervals being added for comparison:

C	D	E	F	G	A	B	C'
1	1·1250	1·2500	1·3333	1·5000	1·6666	1·8750	2
1	1·1224	1·2599	1·3348	1·4983	1·6818	1·8875	2

The scale of equal temperament is not exactly followed in practice, the result being that all keys are not quite the same, the errors being greater as the number of sharps or flats in the scale is increased, and also, in most cases, greater in sharp keys than in flat keys. The precise result depends to a large extent on the individual tuner of the instrument.

Perfectly just intonation may, of course, be obtained in music performed by the human voice, or by instruments of the violin class (*e.g.* a string quartet), so long as no instruments having fixed intervals are employed at the same time. The continued use of tempered scales has, however, largely impaired the sensitiveness of most musical ears to perfect intonation.

Tempera, Painting in. *See* PAINTING (METHODS).

Temperate Zones, North and South. The parts of the Earth's surface lying between the tropics and the Arctic or Antarctic Circle.

Temperature (*Heat*). Temperature is, in popular language, that which determines the hotness or coldness of a body. A hot body is said to have a high temperature, a cold body a low temperature, the terms "high" and "low" being merely relative, and varying within very wide limits according to the circumstances under which they are applied. A body, A, is at a *higher temperature* than a body, B, if, when they are placed in contact, heat flows from A to B. *See* MEASUREMENT OF TEMPERATURE.

——, **Absolute** (*Heat*). *See* ABSOLUTE TEMPERATURE.

——, **Critical** (*Heat*). *See* CRITICAL TEMPERATURE.

——, **Scales of** (*Heat*). *See* THERMOMETRIC SCALES.

Tempering (*Eng., etc.*) The process by which the hardness of steel tools, etc., is regulated according to the purpose for which they are intended. The tool is first hardened by heating to a temperature not exceeding that of a "cherry red," and then suddenly cooled by being plunged into cold water. The steel, if of proper quality, should now be so hard that it will scratch glass; it is however very brittle, and liable to fracture. If the steel be now cautiously heated, it is gradually rendered softer and less brittle; by stopping the heating at the proper moment, and again cooling by immersion in water, the tool may be left with the requisite "temper" for the purpose desired. To enable this to be judged, a portion of the tool is carefully brightened after hardening, so as to expose a clean surface of steel, free from scale or oxide. As the metal is heated, a succession of tints appear on the surface of the metal. These tints change as the temperature rises, and indicate with sufficient accuracy for practical purposes the exact moment when the heating must be stopped. The tints may be classified as in the following table, which also gives the approximate temperature attained, and the principal tools for which each temper is requisite:

	Temp. Fahr.	Tools.
Pale straw ...	430°	Surgical instruments, certain tools for cutting metal.
Darker straw ...	440° to 470°	Metal-working tools, razors, cold chisels, wood-working tools.
Brownish yellow	500°	Axes, plane irons, chipping chisels, and other tools which are subjected to shock or percussion.
Light purple ...	530°	Springs, swords.
Dark purple ...	570°	Saws.

Steel heated to higher temperatures than these becomes too soft for use in cutting tools. The purple tint gives way to a dark lilac, which gradually grows paler, assumes a greenish tint, and ultimately disappears.

In some cases the tempering is effected by covering the object with oil or grease, and heating it until the latter "flashes," or takes fire. This process is termed

Blazing or Blazing Off; it is often applied to saws and springs. In other cases, especially where a number of small objects have to be tempered at the same time, they are heated in a bath of oil, fusible metal, or alloy, to the required temperature. This method is largely used in tempering cutlery.

Tempering (*Pottery, etc.*) Thoroughly mixing clay and bringing it to a suitable condition of plasticity for moulding.

Template (*Build.*) The stone or wood block placed under the bearings of a beam or girder to support and distribute the pressure.

—— *or* **Templet** (*Eng., etc.*) A mould or pattern used to indicate the outline or form which has to be given to a piece of work. A template is usually cut from a thin sheet of wood or metal, the exact form being obtained by careful measurements taken from the working drawings.

Templating (*Eng., etc.*) The making of Templates (*q.v.*) In certain trades (*e.g.* boiler making) it is usual to entrust this operation to a special workman.

Temple (*Weaving*). A flat bar of wood fitted with small pins at each end or other device used in weaving to keep the cloth extended to its proper width to save the strain on the reed caused by the sucking in or shrinking of certain fabrics.

Templet. *See* Template.

Tempo (*Music*). Time, as *tempo di valse*, in the time of a valse; *tempo ordinario*, ordinary time, *i.e.* at a moderate speed.

Temporary Centre (*Eng.*) A piece of wood or metal is sometimes attached temporarily to an object for the purpose of carrying a centre mark which is required during subsequent operations; *e.g.* it may be necessary to find the exact centre of a hole. This must either be filled up or covered over by a piece of material on which the centre can be marked.

Temporary Hardness of Water. *See* Calcium Compounds, Clark's Process, *and* Water.

Temporary Mandrel (*Eng.*) A rod which is passed through a hole in an object such as a hollow tube or cylinder, in order that it may be supported between the centres of a lathe when the outside has to be turned.

Temporary Stars (*Astron.*) *See* Novæ.

Tenacity. *See* Tensile Strength.

Teneramente (*Music*). Tenderly.

Tenerezza, Con (*Music*) With tenderness; delicately.

Tenia (*Architect.*) *See* Tænia.

Tenon (*Carp. and Join.*) The ordinary form of tenon is shown in Fig. 1. A is the tenon proper, or

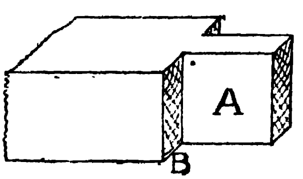


Fig. 1.

portion which fits into the mortice (*q.v.*): B is termed the shoulder of the tenon. Fig. 2 is a Haunched Tenon, the portion C, the Haunch or Haunching, being formed so as to fit into a ploughed groove such as that on the inner edge of the style of a door.

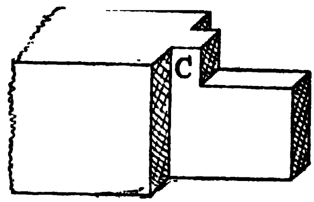


Fig. 2.

Fig. 3 shows a Double Tenon, and Fig. 4 is a Bareface Tenon, which has a shoulder formed on one side only. Fig. 5 shows a Tusk Tenon, used in

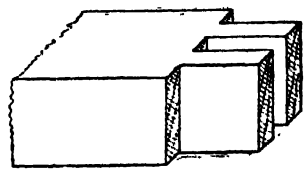


Fig. 3.

framing large structures such as floors. A is the tenon, B the shoulder, and the portion D is termed the Tusk. E is the joist into which the tenon is

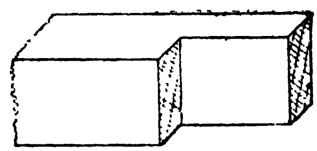


Fig. 4.

morticed, and F a key passing through the tenon. A tenon which does not pass right through the piece into which it is morticed is termed a Stub Tenon or

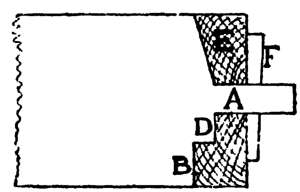


Fig. 5.

Stump Tenon. A Dovetail Tenon has one edge cut at an angle, like a dovetail, and it is held in position against a corresponding sloping side of its mortice by means of wedges. It may pass right through the material, or may form a stump tenon.

Tenoning Machine (*Carp., etc.*) A machine used in cutting tenons. It may consist of saws, two of which work parallel to each other (the distance between them being equal to the width of the tenon), and two more moving in a plane at right angles to the other two, for cutting out the shoulders of the tenon. More modern tenoning machines remove the material at the sides of the tenon by means of rotary cutters consisting of flat plane irons mounted in a revolving block.

Tenon Saw (*Carp. and Join.*) A saw with a parallel blade and an iron or brass back, used for cutting the shoulders of tenons, etc. *See* Saws.

Tenor (*Music*). (1) The highest of men's voices, with the exception of the alto. Generally speaking, the compass is an octave lower than the soprano. (2) The viola (*q.v.*) (3) The largest bell in a peal. A *tenore robusto* is a tenor singer with a full, strong voice. *See also* TENOR CLEF.

Tenor C (*Music*). The C an octave below middle C (*q.v.*)

Tenor Clef (*Music*). The C clef  on the fourth line. *See* STAVE *and* SCORE.

Tenorite (*Min.*) Black oxide of copper. Occurs as a non-crystalline mineral in the form of a powder, in masses, or as concretions. Forms an important copper ore in North America.

Tenor Trombone (*Music*). The trombone in B♭. *See* MUSICAL INSTRUMENTS, *p.* 437.

Tensile Strain (*Eng., etc.*) A strain consisting of an elongation produced in a piece of material by a pull or tensile stress.

Tensile Strength. The property of a material by virtue of which it resists forces tending to produce elongation. The term is sometimes applied to the ultimate stress which a given piece of material can withstand, or to the breaking load.

Tensile Stress (*Eng., etc.*) A force tending to elongate a body.

Tension of Vapour (*Heat*). *See* VAPOUR PRESSURE

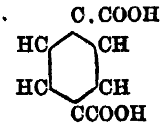
Tension Rods, Bolts, etc. (*Eng.*) Rods or bolts which are used to resist tension. *See also* TIE.

Tenter (*Textile Manufac.*) A machine on which the cloth is stretched after scouring, milling, dyeing, etc. The common form of automatic tenter is horizontal, but it may also be vertical. The cloth passes on travelling tenter hooks over a series of steam pipes. In the blanket trade, in order not only to stretch the cloth, but to retain as much as possible of the natural handle of the wool and whiteness of colour, tentering is done in the open air on vertical frames.

Tenuto (*Music*). Abbreviation *ten.*, held. The term is used to signify that a certain note or chord is to be sustained for its full value. In modern songs, however, the term often signifies that a note is to be sustained for more than its proper length.

Terebene (*Chem.*) A mixture of inactive terpenes, boiling between 156° and 180°. It is a colourless liquid, insoluble in water, soluble in all organic solvents. It has an agreeable odour of pine-wood. Used in medicine in bronchitis and in coughs; it is either inhaled or taken on sugar. To prepare it, redistilled turpentine is shaken with sulphuric acid till its optical activity disappears; then the product is distilled in steam. Dipentene (*see* TERPENES) is an important constituent.

—— *and* **Terebenthene** (*Painting*). On account of the high price of turpentine many preparations have been made which are intended to replace this body, at all events on the market, although there is not one of them which is a really satisfactory substitute from the buyer's point of view. They go under various fancy names, more or less suggestive of turpentine, such as terebene, terebine, terebenthene, turpenteen, *cum multis aliis*. While some of them answer well enough for ordinary work, they all, as stated, fall short of true turpentine, especially in drying and in living power. They may be classed under three heads, those consisting simply of heavy petroleum oils, those consisting of mixtures of petroleum and rosin oils, and those consisting of mixtures of petroleum and rosin oils adulterated with real turpentine. As regards the proportions between the ingredients, each maker has his own recipe, and a good deal of the nomenclature depends upon this circumstance.

Terephthalic Acid (*Chem.*) 

White needles; sublimes on heating without melting; sparingly soluble in water, alcohol, ether, chloroform, and acetic acid. When heated with lime it forms benzene. It is obtained in a number of ways; thus it occurs as an oxidation product on boiling many terpenes with diluted nitric acid. It can be obtained by the diazo reaction (*q.v.*) from paramidobenzoic acid,

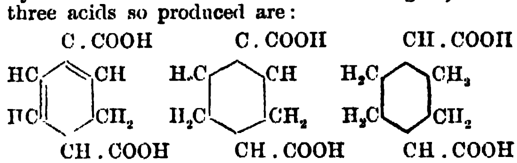
$$C_6H_4\begin{cases}COOH\\NH_2\end{cases} \rightarrow C_6H_4\begin{cases}COOH\\CN\end{cases} \rightarrow C_6H_4\begin{cases}COOH\\COOH\end{cases}$$

from paraxylene by heating it with bromine at 150° to form paraxylylene bromide, digesting the latter with alcohol potassium acetate, heating the acetate with alkaline permanganate, filtering and acidifying the product when the acid separates out:

$$C_6H_4\begin{cases}CH_3\\CH_3\end{cases} \rightarrow C_6H_4\begin{cases}CH_2Br\\CH_2Br\end{cases} \rightarrow$$

$$C_6H_4\begin{cases}CH_2.OOC.CH_3\\CH_2OOC.CH_3\end{cases} \rightarrow C_6H_4\begin{cases}COOH\\COOH\end{cases}$$

The reduction products of terephthalic acid have been carefully studied by Baeyer, who deduced the centric formula for benzene as a result of his work on these compounds. On reduction of the acid with sodium amalgam it adds two atoms of hydrogen in the cold, four atoms on heating, and six atoms with great difficulty (twenty hours' boiling of the tetrahydro acid with excess of sodium amalgam). The three acids so produced are:



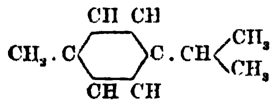
$\Delta^{1,5}$ dihydro-terephthalic acid. Δ^{1} tetrahydro-terephthalic acid. Hexahydro-terephthalic acid.

The $\Delta^{1,5}$ — and Δ^{1} — acids behave like true unsaturated compounds, adding bromine or hydrobromic acid directly, and reducing alkaline permanganate; but the hexahydro acid behaves like a saturated compound, and, although it reacts with bromine, it does so like a saturated fatty acid—that is, hydrogen is replaced by the halogen, and the hydrogen replaced is that attached to the carbon adjacent to the carboxyls. The hexahydro acid is known in two stereoisomeric forms. *See* STEREOISOMERISM. From the formula for terephthalic acid it will be seen that four dihydro acids are theoretically possible. All are known, and the $\Delta^{2,5}$ — acid occurs in two stereoisomeric forms. Two tetrahydro acids are possible, and both are known, the Δ^{2} — acid occurring in two stereoisomeric forms.

Terminal *or* **Terminus** (*Architect.*) An architectural feature, the lower part of which resembles an inverted truncated obelisk, while the upper part is frequently a bust of a man, woman, or satyr.

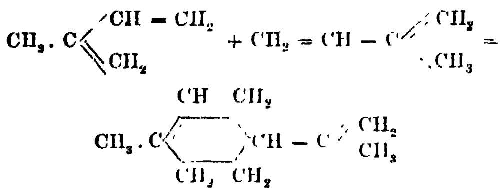
Terminator (*Astron.*) The line which separates the light from the dark portion of a sphere illuminated from one direction.

Terpenes (*Chem.*) Hydrocarbons of the formula $C_{10}H_{16}$. They are mostly ring compounds which may be regarded as related to paracymene,



but a few are open chain compounds of the olefine series. The terpenes and many of their derivatives occur in essential oils. Examples: Oil of bergamotte contains limonene and linalool (*q.v.*), also linalyl acetate; oil of camphor contains camphor (*q.v.*), pinene (*q.v.*), etc.; eucalyptus oil contains cineol and pinene; oil of geranium contains geraniol; oil of lavender contains pinene, limonene, linalyl acetate, geraniol, and cineol; oil of lemons contains citral and limonene; oil of peppermint contains menthol (*q.v.*) and its acetate; otto of roses contains geraniol and citronellol; oil of turpentine contains pinene. ***Except camphene, which is a solid, terpenes are liquids.*** They are volatile in steam; have an agreeable smell; most of them are optically active; some of them resinise on exposure to air and light. *See* PINENE. They polymerise when heated to about 300° to sesquiterpenes and polyterpenes. When caoutchouc is distilled it forms a hydrocarbon called isoprene C_5H_8 of the constitution $CH_2 = CH - C \begin{matrix} CH_2 \\ CH_3 \end{matrix}$

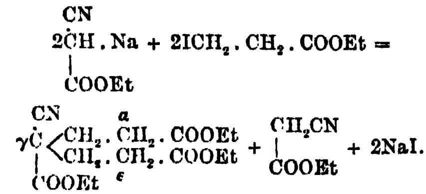
which easily polymerises to dipentene:



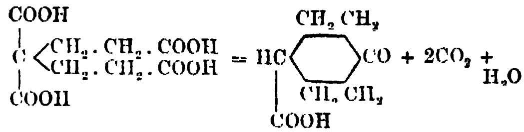
The compound isoprene is called a hemiterpene. Cadinene, an oil which boils at 275° and is found in oils of cade, patchouli, cubebs, galbanum, angostura, and many others, has the formula $C_{15}H_{24}$, and is called a sesquiterpene. So we have

Hemiterpene: Isoprene, C_5H_8.
Terpenes: about 13 of them $= 2 \times C_5H_8 = C_{10}H_{16}$.
Sesquiterpenes: few definitely known $= 3 \times C_5H_8 = C_{15}H_{24}$.
Polyterpenes: none exactly studied $= N \times C_5H_8 = (C_5H_8)_n$.

For the properties of a typical terpene, *see* PINENE. Another terpene of great interest and importance is *Limonene*, which contains an asymmetric carbon atom, and is known in its dextro, lævo, and racemic forms; the racemic form is called *Dipentene*. This terpene has recently been synthesised by Professor Perkin, and it is the first direct synthesis of a terpene which has ever been made. Ethyl β-iodopropionate and ethyl sodiumcyanacetate (from sodium ethoxide and ethyl cyanacetate) react at the ordinary temperature to form ethyl γ-cyanopentane-αγε-tricarboxylate,

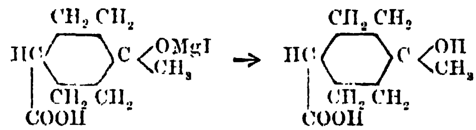


This ester is hydrolysed with hydrochloric acid, and the resulting acid heated with acetic anhydride:

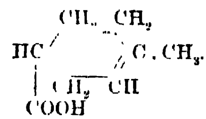


δ-ketohexahydrobenzoic acid.

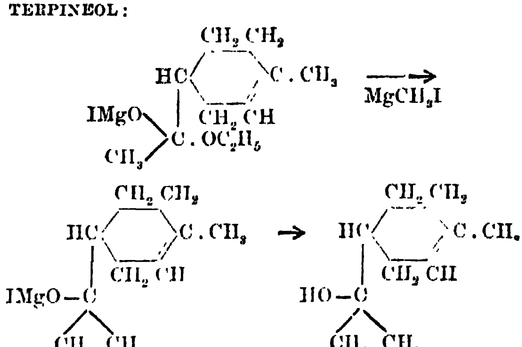
The ethyl ester of this acid yields on treatment with magnesium methyl iodide in ether, and hydrolysis of the product δ-hydroxyhexahydroparatoluic acid:



On solution of the lactone of this acid in fuming hydrobromic acid, the hydroxy group is replaced by bromine giving δ-bromhexahydroparatoluic acid, from which pyridine removes hydrogen bromide, giving Δ^3 – tetrahydroparatoluic acid:

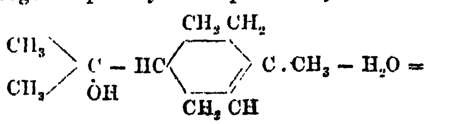


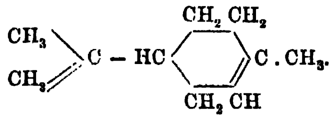
The ethyl ester of this acid with magnesium methyl iodide in ether yields an addition product which is decomposed by water with formation of inactive TERPINEOL:



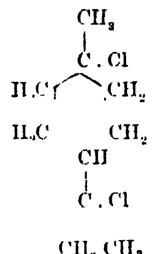
Terpineol.

Terpineol when heated for an hour with potassium hydrogen sulphate yields dipentene by loss of water:

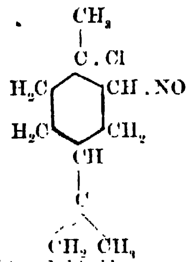




Dipentene is a colourless liquid; boils at 180°; has a smell of lemons; soluble in ether, alcohol, benzene, acetic acid; it occurs in a number of essential oils, *e.g.* cubebs, thyme, worm seed; and as it is formed from some other terpenes (camphene, pinene, and the limonenes at 250 to 300°) at a high temperature, it occurs in those turpentines which are distilled at a high temperature, namely, Russian and Swedish. It is formed by the union of equal quantities of *d*- and *l*-limonene, and from terpineol as described above; and along with other products from pinene by boiling with alcoholic sulphuric acid. To obtain pure dipentene its dihydrochloride is boiled with acetic acid and sodium acetate, the product distilled in steam, and the dipentene further purified by boiling with caustic potash, again distilling in steam, and fractionally distilling the dipentene. Dipentene adds four atoms of bromine directly to its molecule; it adds two molecules of hydrogen chloride, or hydrogen bromide. The dihydrobromide is known in two forms, *cis* and *trans*. Dipentene dihydrobromide is also formed by the addition of hydrogen bromide to limonene, cineol, and terpin. Dipentene also adds nitrosyl chloride molecule for molecule:

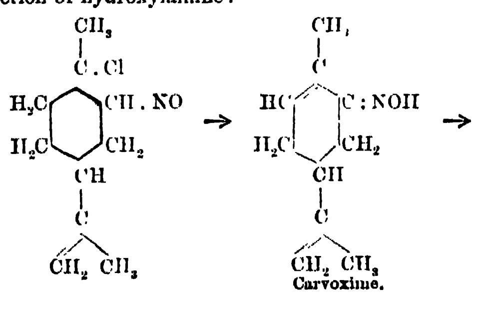


Dihydrochloride.

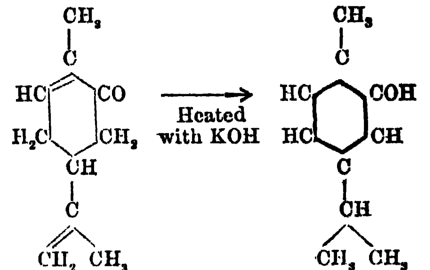


Nitrosyl chloride compound.

In the case of the **limonenes** hydrogen chloride is added in two stages, the first molecule being added on when dry hydrogen chloride is used, and the second when moist hydrogen chloride is used; as the first product is optically active, the addition must occur at the side chain. As regards the limonenes, the nitrosyl chloride compounds are active, and each limonene yields two stereoisomeric nitrosyl chlorides; since these are all active, addition must occur in the ring. When the nitrosyl chlorides are treated with alcoholic potash they yield the carvoximes $\{$d-, l-, and (d + l)$\}$ compounds, which are formed from carvone by the action of hydroxylamine:



Carvoxime.



Carvone. Carvacrol (*q.v.*)

As dipentene contains an asymmetric carbon atom, and is optically inactive, it should be composed of two oppositely active constituents; these constituents are the dextro and lævo limonenes. The limonenes occur in many essential oils (*see above*), and when mixed in equal quantities they yield dipentene. The remaining ring terpenes cannot be described here. Of the open chain, or olefinic terpenes, none has had its constitution settled beyond all doubt. As an example of this class of terpene *Myrcene* may be mentioned, which occurs in bay oil; as it passes into linalool (*q.v.*) by addition of the elements of water it has most probably the constitution

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>C:CH-CH_2-CH_2-\underset{CH_2}{C}-CH=CH_2 \quad \text{or}$$

$$\begin{matrix}CH_3\\CH_2\end{matrix}\!\!>C-CH_2-CH_2-CH_2-\underset{\underset{CH_2}{\|}}{C}-CH=CH_2$$

A few important derivatives of the terpenes are appended. *Citral*,

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>C:CH.CH_2.CH_2.\underset{CH_3}{C}:CH.CHO$$

is a colourless oily liquid, boils at 228° to 230°, and smells of lemons. Heated with acid potassium sulphate it yields paracymene; boiled with caustic it yields methyl heptenone,

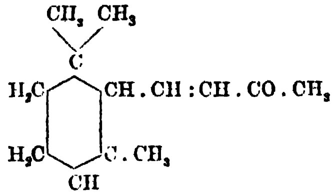
$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>C:CH.CH_2.CH_2.CO.CH_3;$$

reduced by sodium and alcohol it yields the corresponding alcohol geraniol. It unites with acid sodium sulphite. Citral is known in two stereoisomeric forms. With acetone in presence of alkali, citral condenses (shaken for several days with baryta water) to pseudo-ionone:

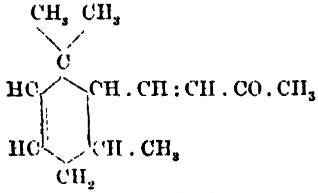
$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>C:CH.CH_2.CH_2.\underset{CH_3}{C}=CH.\underset{\underset{HC.CO.CH_3}{\|}}{CH}$$

This compound is known in two stereoisomeric forms. When pseudo-ionone is heated for some hours with dilute sulphuric acid and glycerine, it forms *Ionone*, which is a liquid boiling at 128° under a pressure of 12 mm. mercury, and in dilute alcoholic solution smells of violets and vine-blossom—hence it is largely used as a perfume.

Ionone is a mixture of two stereoisomers; its formula is—



The natural perfume of violets is due to a compound called *irone*, isomeric with ionone:



Citronellol, also called *Rhodinol*,

$$\begin{matrix} CH_3 \diagdown \\ CH_3 \diagup \end{matrix} C:CH.CH_2.CH_2.\underset{CH_3}{CH}.CH_2.CH_2OH$$

is one of the principal constituents of otto of roses; it is an oil smelling strongly of roses, boils at 117° under 17 mm. pressure, and is lævorotatory. The inactive form has recently been synthesised, so that its constitution is now quite certain: Sodium ethyl acetoacetate and ethylene dibromide give

$$\begin{matrix} CH_3 \\ | \\ CO \\ | \\ CH.CH_2.CH_2Br \\ | \\ COOEt \end{matrix}$$

which on saponification with caustic potash yields $CH_3CO.CH_2.CH_2.CH_2OH$. With hydriodic acid this alcohol gives its iodide, which is condensed with acetone and zinc to methyl heptenone,

$$CH_3.CO.CH_2.CH_2.CH_2I + Zn + CO(CH_3)_2 =$$
$$ZnIOH + CH_3.CO.CH_2.CH_2.CH:C \begin{matrix} CH_3 \\ CH_3 \end{matrix}$$

This ketone gives the ethyl ester of geranic acid when condensed with zinc and ethyl iodacetate

$$\begin{matrix} CH_3 \diagdown \\ CH_3 \end{matrix} C:CH.CH_2.\underset{OH}{C}:CH_2 + Zn + ICH_2.COOEt =$$

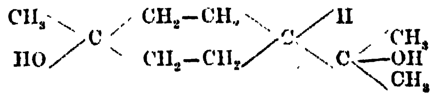
(Tautomeric form.)

$$ZnOHI + \begin{matrix} CH_3 \\ CH_3 \end{matrix} \rangle C:CH.CH_2\ CH_2.C.CH_3$$
$$\qquad\qquad\qquad\qquad\qquad \underset{}{CH.COOEt}$$

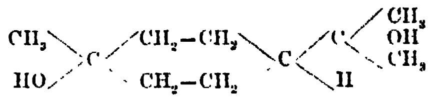
This ester reduced by sodium and alcohol to the ethyl ester of citronellic acid, then to inactive rhodinol. It is used in perfumery; thus an artificial otto of roses is made (patented) as follows: 80 parts geraniol, 10 parts rhodinol, 1 part phenylethyl alcohol, 2 parts linalool, 0·25 parts citral, and 0·5 parts octyl aldehyde. *Geraniol*,

$$\begin{matrix} CH_3 \diagdown \\ CH_3 \end{matrix} \rangle C:CH.CH_2.CH_2.\underset{CH_3}{C}:CH.CH_2OH$$

occurs in oil of geranium and in otto of roses; it is an oil which smells of roses and geraniums; boils at 229°, and is optically inactive. It is the alcohol corresponding to citral, which it yields on careful oxidation; it unites with calcium chloride; heated with water at 200° it is in part rearranged to linalool (*q.v.*); dilute sulphuric acid converts it to terpineol. *Terpin* is a dihydric alcohol, and is known in the cis- and trans-forms (*see* STEREOISOMERISM):

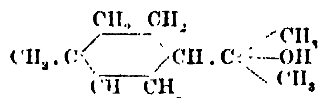


Cis-form M.P. 104°.

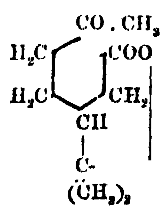


Trans-form M.P. 264°.

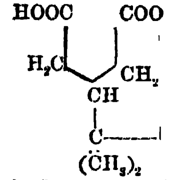
They are both white crystalline solids obtained from the corresponding cis- and trans- limonenedihydrobromides by converting them into acetates by means of silver acetate and saponifying the esters with alcoholic potash. They can be reconverted by shaking with hydrobromic acid. Dehydrating agents readily convert them into dipentene. The cis-terpin readily takes up a molecular proportion of water forming *Terpin hydrate*, which is a well crystallising solid; melts at 120° when rapidly heated, giving off steam, and passing into terpin again. The halogen acids give the cis- and trans-dipentenedihalogen acid addition products. Boiled with dilute acids it yields terpineol and other products. It is formed from turpentine by the action of dilute nitric acid and alcohol, from the dihydrochlorides of dipentene and d-limonene by the action of water, and from linalool (*q.v.*), geraniol, and terpineol by the action of dilute acids. *Terpineol*,



is a white crystalline solid which melts at 35°, but shows to a remarkable degree the property known as superfusion, so that it is commonly met with as a liquid; boils at 215° to 218° (134°—135° at 60 mm.); it has a pleasant smell of lilac. It forms a nitrosochloride; also a phenylurethane with phenyl isocyanate, which melts at 113°. $CO\begin{matrix} \diagup NHC_6H_5 \\ \diagdown OC_{10}H_{17} \end{matrix}$ When shaken during three days with benzene and 5 per cent. sulphuric acid, it passes into terpin hydrate. Distilled with acid potassium sulphate (*see above*) it gives dipentene. On oxidation with chromic acid it yields a ketolactone of the formula—



which on further oxidation with potassium permanganate yields acetic and terpenylic acids—

$CH_3 . COOH$ and 

Terpineol has been synthesised (*see above*). It is obtained by allowing French turpentine to stand for twelve hours with ·5 parts concentrated sulphuric acid and 1·5 parts of 90 per cent. alcohol; or by heating terpin hydrate with 1 per cent. sulphuric acid, then crystallising and purifying by fractional distillation. Terpineol is largely used as a perfume, alone as in scenting soap, or mixed with other perfumes.

Terra Alba (*Dec.*) This is powdered gypsum (*q.v.*) The mineral is prepared merely by grinding. It answers better as a water colour than with oil, as it has more body with water than with the latter vehicle. It is a very pure white, except when tinged yellow by iron. It can, however, be purified from iron by treatment with dilute hydrochloric acid. It is absolutely permanent to light and air and chemical action, being as permanent as barytes itself. In spite of its cheapness, its want of body (*q.v.*) is a great bar to its use. Paper makers and stainers are probably the largest users of it. In use with paper, body is not of very great importance, and gypsum combines the advantages of permanence, cheapness, and miscibility with all other pigments. Moreover, its cheapness secures it from adulteration, but it would be even cheaper were not large quantities of gypsum used for the manufacture of plaster of Paris. This substance can also be used as an oil paint (it sets hard with water), but is inferior to the unburnt gypsum.

Terracotta. A hard pottery, generally unglazed, composed of fine clay, fine grained sand, crushed pottery, or other similar materials. The colour varies with the materials used, but terracotta is sometimes specially coloured. Used as a building material and for small works of art, *e.g.* statuettes. *Cf.* TANAGRA FIGURINES.

Terra di Sienna (*Paint.*) A ferruginous earth of a fine yellow colour, used as a pigment in oil and water colour painting. It is known respectively as raw or burnt sienna (*q.v.*)

Terra Nera (*Paint*). An unctuous black pigment used by ancient artists in tempera, fresco, and oil painting.

Terrestrial Equator (*Astron.*) *See* EQUATOR, TERRESTRIAL.

Terrestrial Magnetism (*Elect.*) The phenomena arising from the magnetic properties of the earth. *See* DIP, DECLINATION, MAGNETIC ELEMENTS, *etc.*

Terrestrial Radiation (*Meteorol.*) The escape of heat from the earth's surface into the atmosphere.

Terre Verte, Terra Verde (*Paint.*) Genuine terre verte is essentially a silicate of iron and magnesia, found native in many places. It occurs in the Mendip Hills, and two other important localities are Cyprus and Verona, whence the name Verona Earth. The pigment requires no preparation beyond grinding. It varies much in hue according to the locality from which it was obtained, but there is always a bluish grey tinge about it. It is absolutely permanent in air, and, curiously enough, resists sulphurous fumes perfectly, in spite of the fact that it contains iron. It can be mixed with any other pigment and can be used either as a water or as an oil colour. It has very little body, and occupies an intermediate place between the body colours and the glazing colours. Copper greens are sometimes fraudulently sold as terre verte, but this is at once detected if the substance is exposed to the action of sulphuretted hydrogen, which has no effect on genuine terre verte, but blackens copper greens. Dilute acids again have little action on terre verte, but dissolve copper greens, forming a solution which is turned blue by ammonia.

Tertiary (*Geol.*) The TERTIARY ROCKS embrace those strata newer than the SECONDARIES (*i.e.* the Chalk), but older than the most recent formations, *e.g.* the Glacial deposits. *See* STRATA, TABLE OF (*in Appendix*).

Tertiary Alcohols (*Chem.*) Alcohols of the formula $\begin{matrix}R_1\\R_2\\R_3\end{matrix}\!\!>\!C.OH$, where R_1, R_2, R_3 are monovalent hydrocarbon residues which may be the same or different. Examples:

$$\begin{matrix}CH_3\\CH_3\\CH_3\end{matrix}\!\!>\!C.OH \qquad \begin{matrix}CH_3\\CH_3\\C_2H_5\end{matrix}\!\!>\!C.OH$$

Trimethyl carbinol. Dimethylethyl carbinol.

They are liquids with a smell resembling that of camphor; they lose water somewhat readily on heating, forming olefines, *e.g.* $(CH_3)_3COH$ gives $(CH_3)_2C:CH_2$. On oxidation they yield acids containing a smaller number of carbon atoms than the original alcohol; thus trimethylcarbinol yields acetic acid, but also acetone and a little isobutyric acid $(CH_3)_2CH.COOH$. Their nitro-derivatives are distinguished from those of primary and secondary alcohols by being unacted upon by nitrous acid. They are obtained by the action of zinc alkyls on acid chlorides; or by absorbing suitable olefines in sulphuric acid and distilling the product with water; *e.g.*:

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!CH.CH_2OH \xrightarrow[\text{with } H_2SO_4]{\text{Heated}} \begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!C:CH_2 \text{ with } H_2SO_4$$

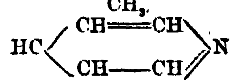
Isobutyl alcohol.

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!CHSO_4.CH_3 \xrightarrow[H_2O]{} \begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!C\!<\!\begin{matrix}OH\\CH_3\end{matrix}$$

Tertiary Amines (*Chem.*) Compounds in which an atom of nitrogen is united to three hydrocarbon radicals. Example: Trimethylamine (*q.v.*)

Tertiary Bases (*Chem.*) Compounds of the formula $\begin{matrix}R_1\\R_2\\R_3\end{matrix}\!\!>\!N$ or $\begin{matrix}=C\\-C-\end{matrix}\!\!>\!N$ where R_1, R_2, R_3 are radicals united to the nitrogen atom by carbon and $\begin{matrix}=C\\-C\end{matrix}\!\!>\!N$ is part of a ring. Examples:

Trimethylamine $\begin{matrix}CH_3\\CH_3\\CH_3\end{matrix}\!\!>\!N$

Pyridine 

All tertiary bases add alkyl iodides, directly forming quaternary ammonium iodides, *eg.* $N(CH_4)_4I$.

Tertiary Colours (*Paint.*) *See* COLOURS, TERTIARY.

Tertiary Hydrocarbons (*Chem.*) Hydrocarbons which contain one or more carbon atoms united to four other carbon atoms—*eg.* Hexamethylmethane.

$$\begin{array}{ccccccc} & & CH_3 & & CH_3 & & \\ & & | & & | & & \\ CH_3 & - & C & — & C & - & CH_3 \\ & & | & & | & & \\ & & CH_3 & & CH_3 & & \end{array}$$

See also PARAFFINS.

Tesla Coil (*Elect.*) A name applied to an induction coil for producing currents of very high potential and frequency. The primary coil consists of a few turns of thick wire, without any iron core; through this coil pass the rapidly oscillating currents produced by the discharge across an air-gap of a Leyden jar or other condenser, which is itself charged by means of an induction coil of the ordinary type, or by a transformer which is wound so as to give a secondary current of very high voltage. An oscillatory discharge (*q.v.*) occurs through the primary of the Tesla coil, and this induces a secondary current of exceedingly high voltage and frequency in the secondary winding, which consists usually of one layer of fine wire, wound on an insulating cylindrical support. In some cases both coils are immersed in a bath of oil, the apparatus being then often termed an OIL COIL; but in most modern forms air insulation is found to be sufficient.

Tesselated Pavement (*Dec.*) A floor formed of small coloured tiles laid in geometrical patterns. *Cf.* MOSAIC.

Test (*Chem., Phys., etc.*) (1) An experimental operation undertaken to ascertain the nature, condition, strength, or other properties of a given substance, apparatus, structure, etc. (2) A reagent or substance used in making such a test.

—— (*Eng.*) An operation carried out in order to ascertain the strength, quality, or other properties of some material, structure, or machine.

—— (*Zool.*) The hard external or rigid parts of an organism.

Testa (*Botany*). The term applied to the coat of a seed. When an inner seed coat is present it is termed the endopleura or tegmen. The testa may become hard and woody, as in the so-called Brazil nut. The "husk" of the sunflower and similar "seeds" is the fruit wall, not the testa.

Test Bars (*Eng.*) Bars of metal, etc., suitably shaped for testing in a testing machine or otherwise. Test bars are often made of the same material as that employed in the execution of an order, so that the quality of the material used can be accurately determined; the conditions to be satisfied are frequently laid down in the specification.

Test Cocks (*Eng.*) Small cocks in a steam boiler, one being fixed above, the other below, the water line, in order to indicate the level of the water inside.

Testing Machine (*Eng.*) A machine by means of which a known stress of large amount can be applied to a suitable piece of material, in order to measure its elastic constants or its breaking strength. The form of testing machine most commonly met with is one by which a tensile or compressive stress is applied to a rod or bar. One end of the bar is firmly gripped by strong jaws attached to the ram of a hydraulic press: the other end is similarly connected to the shorter arm of a lever. The longer arm of this lever carries a weight which can be moved along the arm till the pull exerted on the bar is counterbalanced and the lever brought into a position of equilibrium. The lever is graduated after the manner of a steelyard, so that by observing the position of the weight at any instant the amount of the force acting on the bar can be read off. The extension produced in the bar is measured by various methods—a reading microscope or cathetometer, a purely mechanical device, or some combination of optical and mechanical apparatus, such as the Extensometer of Ewing. Recording apparatus is sometimes constructed so as to trace automatically a curve on paper showing the relation of the stress and strain in the bar throughout the experiment. Testing machines are also constructed for applying and measuring transverse, torsional, or compressive stresses.

Testing of Drains. *See under* SANITATION.

Test Specimens (*Eng.*) *See* TEST BARS.

Tetartohedrism (*Min.*) The possession by a crystal of only one-fourth of the number of faces which are required by the symmetry of the system to which the crystal belongs. *See also* SYSTEMS OF CRYSTALS.

Tetrachord (*Music*). A series of four sounds; the half division of modern scales. *See* SCALE *and* TEMPERAMENT.

Tetradymite (*Min.*) A mineral allied to BISMUTHINE (*q.v.*) It is a sulphide of lead, but contains in addition some tellurium.

Tetragonal (*Min.*) *See* SYSTEMS OF CRYSTALS.

Tetrahedrite *or* **Fahlerz** (*Min.*) A sulphide of copper and antimony, with other metals; copper 38·6, sulphur 26·3, antimony 16·5, arsenic 7·2, with iron, zinc, and silver. The latter mineral may be present in considerable quantity (*e.g* 30 per cent.), and the mineral is then termed SILVER FAHLERZ or ARGENTIFEROUS GREY COPPER ORE. Cubic System, also massive. Colour grey to black. Cornwall, Devon, Scotland, Central Europe, N. America. It is an important ore of Copper, and also of Silver.

Tetrahedron. A pyramid having a triangular base.

Tetrastyle (*Architect.*) A term applied to a temple which has four columns in the front row. *See* DISTYLE, DECASTYLE, HEXASTYLE, OCTASTYLE.

Tetratomic Molecules (*Chem.*) A term applied to elements having molecules composed of four atoms. Such elements are phosphorus and arsenic at a temperature of about 1,000°. *See also* MOLECULE.

Tetravalent Element *or* **Group** (*Chem.*) *See* VALENCY.

Tetronal (*Chem.*) (Propione diethyl sulphone, *or* diethyl sulphone diethylmethane.) A white crystalline solid; melts at 85°. It is prepared and acts like sulphonal (*q.v.*)

Th (*Chem.*) The symbol for Thorium (*q.v.*)

Thalassic Deposits (*Geol.*) *See* DEEP SEA DEPOSITS.

Thallium (*Chem.*), Tl. Atomic weight, 204. A rather rare white metal; melts at 294°; boils about 1500°. Its vapour density at 1725° shows it to have a diatomic molecule, but the lowering of the vapour pressure in mercury solution points to its having a monatomic molecule when in solution in mercury. Its specific gravity is near that of lead, being 11·9.

In air it is easily oxidised to the monoxide Tl_2O. It dissolves readily in sulphuric and nitric acids, dilute or strong: less readily in hydrochloric acid owing to the low solubility of its chloride (0·265 in 100 at 16°) in water. On solution in these acids it forms thallous salts. The metal was discovered, and is readily detected, by its flame spectrum—a single bright green line. Thallium occurs in small amount in some kinds of iron and copper pyrites, in a Swedish mineral called crookesite, and in a number of mineral springs. One method of obtaining thallium is to boil the flue dust from pyrites which contains thallium, with water, and precipitate the clear solution with common salt; the crude thallous chloride so precipitated is washed with common salt solution; transformed into sulphate and again precipitated with common salt—this removes arsenic; about 30 to 50 grams of pure chloride are obtained from 3,000 grams of dust. The chloride is converted into the acid sulphate by heating with sulphuric acid, dissolved in water, and the solution electrolysed, using a platinum anode and a copper cathode: the metal separates in large shining leaves and needles; it is quickly washed and may be melted under potassium cyanide. The position of this element in the Periodic System (Group III., Series 11) scarcely gives a correct idea of its chemical relationships. The thallous salts have formulæ corresponding to those of the alkali metals (K : Na). The oxide Tl_2O, which is black, dissolves in water forming a hydroxide TlOH, which is also soluble in water, with strong alkaline reaction and the property of absorbing carbon dioxide to form the soluble carbonate Tl_2CO_3. The chloride TlCl crystallises in cubes like common salt, but is sparingly soluble in water like lead chloride; yet, like potassium chloride, it forms an extremely sparingly soluble platinum double chloride, Tl_2PtCl_6. The bromide (pale yellow) and the iodide (bright yellow) are much less soluble than the chloride. The sulphate is isomorphous with potassium sulphate, but less soluble in water, and it forms sulphates of the type $Tl_2SO_4MSO_46H_2O$ where M = Fe, Mg, or Ni, and also alums; its sulphide is black, insoluble in water, but soluble in acids. Like aluminium, which occurs in the same group, it forms an oxide, thallic oxide, Tl_2O_3, which is obtained by burning the metal in oxygen; but it is a brownish black solid, and quite unlike aluminium in that it behaves as a pretty typical peroxide. Derived from this oxide are a few unstable salts of the same type as the aluminium salts, but far more readily hydrolysed by water, and the thallic sulphate $Tl_2(SO_4)_3$ does not appear to form alums.

Thallophyta (*Botany*). A subdivision of the Plant kingdom comprising the plants lower than mosses and liverworts—namely, the Algæ and Fungi. They are characterised by having a simple plant body or thallus.

Thallus (*Botany*). A term applied to the simple plant body of the Algæ and Fungi. Usually there is but little separation into root, stem, and leaf. A thallus may be filamentous or membranous, unicellular or multicellular.

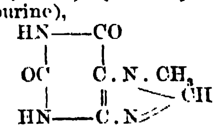
Thebaine (*Chem.*) $C_{19}H_{21}NO_3$. An alkaloid occurring to the extent of about 0·15 per cent. in opium. It is a white crystalline solid; melts at 193°; nearly insoluble in water, soluble in alcohol; lævorotatory. Its constitution is not settled, but it is a tertiary base. It contains two methoxy groups and a reduced phenanthrene ring. It produces convulsions when administered to animals.

Theine (*Chem.*) Another name for CAFFEINE (*q.v.*)

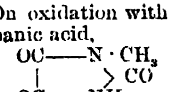
Theme (*Music*). The principal subject of a musical composition.

Thenard's Blue (*Dec.*) This is a cobalt pigment containing alumina. Thenard originally prepared it from Swedish cobalt ore, but it is now usually made by precipitating mixed solution of a cobalt salt (usually the nitrate or the sulphate) and alum with carbonate of soda. The filtrate is filtered off, washed, dried, and ignited at a red heat. It is hardly possible to use too high a temperature, and the fiercer the heat the greater will be the resistance of the pigment to external influences. Cobaltous sulphate, ignited when mixed dry with ammonia alum, also gives Thenard's blue, but prolonged ignition is necessary. In all cases the alum must be free from iron, a very common impurity, or the purity of the blue will be spoiled by the presence of brownish red sesqui-oxide of iron. Various other processes have been employed for making this blue. Binder precipitated hydrate of alumina with potash and chloride of cobalt with ammonia in separate vessels and mixed the precipitates in suspension in water after they had been thoroughly washed and dried, and ignited the mixture. The shade of the pigment varies with the proportions of the two metals present. A rough average is probably 80 per cent. of alumina and 15 per cent. of cobaltous oxide. According to Bouillai Marillai, a very rich and velvety blue is obtained by substituting phosphate of lime for alumina. The phosphate of lime and cobalt oxide are precipitated separately according to Binder's principle, and then mixed. An equally good result can, however, be obtained by making a paste of freshly precipitated alumina with a strong solution of cobalt chloride, drying the paste, and then grinding the dry mass to a fine powder, and heating it to a white heat for an hour. This last process entirely obviates the red tint which is often the great drawback of Thenard's blue. It must be remembered that whenever Thenard's blue is made by ignition it must be completely shielded from the combustion gases by heating it in crucibles with tightly luted lids. If the pigment has been exposed to the gases its colour is always dull and uncertain. Thenard's blue is quite unchanged by exposure to air and light, and few chemicals have any action upon it. It can be used either as an oil or as a water colour, and can be mixed with any other pigment whatsoever.

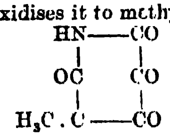
Theobromine (*Chem.*) (Dimethylxanthine, 3 : 7-dimethyl-6-oxy-purine),



A micro-crystalline solid; sublimes without decomposition when carefully heated at 290° to 295°; slightly soluble in water; only sparingly soluble in alcohol, ether, chloroform. Behaves both as a feeble base and acid. On oxidation with chromic acid it gives methylparabanic acid,



Chlorine water oxidises it to methyl alloxan,



It yields a crystalline silver salt when its boiling ammonia solution is precipitated with silver nitrate, and this silver salt when heated with methyl iodide gives caffeine (*q.v.*) The physiological action of theobromine is similar to but stronger than that of caffeine. It occurs to the extent of ½ to 2 per cent. in cocoa beans, and is prepared from them by finely powdering, extracting by boiling water, precipitating with lead acetate, and freeing the clear filtrate from excess of lead by sulphuretted hydrogen. On evaporating the clear filtrate to dryness and extracting with boiling alcohol a solution is obtained which deposits theobromine on cooling. Theobromine is used to a small extent in medicine, and the salicylate of its sodium salt is also used under the name Diuretin. Theobromine is synthesised from xanthine (*q.v.*) by heating its lead salt with methyl iodide at 100°. *See also* PURINES.

Theodolite (*Surveying*). The principal instrument used in surveying. It consists essentially of a small telescope, mounted on a suitable stand, and capable of rotation about both its horizontal and vertical axes. It is fitted with graduated scales for the accurate determination of the amount of angular movement in either plane, and with screws for the levelling of the instrument. *See* SURVEYING.

Theorem of Three Moments (*Eng.*) *See* THREE MOMENTS, THEOREM OF.

Thermal Conductivity (*Heat*). This is defined as follows: Let there be a plate of any material of area A and uniform thickness d; let the sides be maintained at temperatures t_1 and t_2, and let H units of heat pass through the plate in T seconds. Then if k be the thermal conductivity of the material,

$$H = k\frac{A(t_1 - t_2)T}{d}$$

From this equation it appears that the thermal conductivity is the quantity of heat which passes in unit time through unit area of a plate of unit thickness, when unit difference of temperature is maintained between its two sides.

Thermal Efficiency of an Engine (*Heat*). *See* PERFECT ENGINE.

Thermal Unit (*Heat*). The unit in which heat is measured is the quantity of heat necessary to raise unit mass of water, through unit rise of temperature. The unit of mass is usually the pound or gram, the unit rise of temperature is 1° Fahrenheit or 1° Centigrade. This definition is sufficiently exact for most purposes, but the actual value varies with the initial temperature. This fact may be otherwise expressed by saying that the Specific Heat of water is not quite constant. *See also* CALORIE.

Thermal Value. The amount of heat obtained by the complete combustion of a given quantity of some fuel.

Thermite (*Chem.*) The mixture of aluminium powder and ferric oxide used in Goldschmidt's process (*q.v.*)

Thermo-Chemistry. That branch of chemistry which deals with the measurement of the heat evolved or absorbed in reactions, and which applies the results of such measurements to the solution of various chemical problems, such as the determination of constitution, etc. The measurements of heat can be made either in terms of the units of heat or work, *viz.*:

The small calorie = the heat required to raise one gram of water through 1° C. at 18° C.—denoted by cal.

The large calorie = 1000 small calories—denoted by Cal.

The erg = $2{\cdot}391 \times 10^{-8}$ cal.

The joule = 10^7 ergs = 0·2391 cal.—denoted by j.

The kilojoule = 1000 j = 239·1 cal.—denoted by Kj.

[1 cal = $4{\cdot}183 \times 10^7$ ergs = J.]

The quantities of substances used in the experiments may be any that are convenient, but the results should be referred to the gram molecule. Thus when hydrogen burns in chlorine to form hydrogen chloride, the heat evolved in the formation of 36·5 grams of hydrogen chloride is now the usual way of expressing the result: it is equal to 22,000 cal, or 92 Kj. In practice, only reactions which proceed quickly can be investigated, such as those between acids and bases, combustions, and the like. The apparatus employed for reaction of the first kind may be an ordinary calorimeter; for reactions of the second kind a "bomb" apparatus devised by Berthelot and Vieille is used; it consists of a strong steel vessel coated inside with platinum and provided with a rod which supports a platinum dish (in which a known weight of the substance is placed), and also serves as a support for one end of a small iron spiral of known weight, the other end of which is supported by a second rod; both rods are attached to wires which pass to the outside. The vessel is provided also with a screw valve, so that compressed oxygen can be introduced (25 atmospheres or more). A vessel containing a known quantity of water surrounds the combustion chamber, the temperature of the water being registered by a thermometer which will allow at least $\frac{1}{500}$ of a degree to be read; surrounding the water chamber is a vessel containing dry air, and highly polished inside. Solids or non-volatile liquids may be placed directly in the platinum dish; volatile liquids are put in collodion balloons; substances which cannot be ignited in this way are mixed with a known weight of a substance such as naphthalene. When the current is passed, the iron spiral is fused and ignited, and the drops of burning iron ignite the substance. The water equivalent of the bomb must be known, and of course the heat of combustion of the iron spiral and any added substance must be deducted from the result. When the heat evolved in a reaction cannot be measured directly, or when it is desired to obtain the heat of formation (*q.v.*) of a compound which is not formed by the direct union of its elements, indirect methods are employed. These indirect methods are based on what is known as the Law of Constant Heat Summation (see this for an example given in full). An enormous amount of thermochemical data has been accumulated, but little use is made of it in pure chemistry. In applied science the thermo-chemistry of fuel is of great importance; in physiology the heat value of food is of some importance, for practically all the heat of the body is due to chemical changes occurring in it. A few examples of results in pure chemistry are appended:

$$\begin{aligned}(1)\quad 2Al + 3O &= Al_2O_3 + 754 \text{ Cal.}\\ C + O_2 &= CO_2 + 93{\cdot}6 \text{ Cal.}\\ 4Na + O_2 &= 2Na_2O + 2 \times 100 \text{ Cal.}\\ 4Fe + 3O_2 &= 2Fe_2O_3 + 2 \times 19{\cdot}5 \text{ Cal.}\end{aligned}$$

Hence it may be inferred that aluminium oxide will not be reduced to the metal by heating it with carbon or with sodium, but that if aluminium were heated with ferric oxide or with sodium oxide it would be capable of reducing them to the metal. The Goldschmidt process (*q.v.*) is an application of a knowledge

of the high heat of formation of aluminium oxide to a useful purpose.

(2) $H_2 + I_2 = 2HI - 2 \times 60{\cdot}5$ Cal.
$H_2 + I_2 + aq = 2HI\ aq + 2 \times 13$ Cal.

Thus it will be seen that hydrogen iodide is formed from hydrogen and solid iodine, with considerable absorption of heat. When the gas is dissolved in water, heat is evolved until the solution attains a specific gravity of 1·56 (about 50 per cent. HI), after which no more heat is evolved, although a solution of sp. gr. 1·7 (about 58 per cent.) can be obtained. It has been suggested that the reducing action of concentrated hydriodic acid is due to this 8 per cent. or so of the endothermic hydrogen iodide, which evolves no heat on solution.

(3) The heats of formation of the halogen compounds of the elements are periodic functions of the atomic weights of the elements.

(4) In organic chemistry there is a fairly constant increase in the heat of formation for an increment of CH_2 in homologous series. Heats of neutralisation of isomeric bases are occasionally of use in determining constitution; thus the heat of neutralisation with hydrochloric acid for

Aniline is . . .	74 Kj.
o-chloraniline is .	63 „
m-chloraniline is .	66 „
p-chloraniline is .	72 „

Stohmann has attempted to show that in the benzene ring there are not three equal valued double bindings by comparing the increase in the heat of combustion on addition of hydrogen to the ring in the case of benzene and phthalic and terephthalic acids. An example is:

Benzene to dihydrobenzene	+68·2 Cal.
Dihydrobenzene to tetrahydrobenzene .	+44·0 Cal.
Tetrahydrobenzene to hexahydrobenzene	+41·2 Cal.
Hexahydrobenzene to hexane . . .	+58·0 Cal.
Phthalic acid to dihydro acid . . .	+68·7 Cal.
Dihydro acid to tetrahydro acid . . .	+45·3 Cal.
Tetrahydro acid to hexahydro acid . .	+45·3 Cal.
Hexahydro acid to suberic acid . . .	+54·8 Cal.

It will be seen that a much larger amount of heat is evolved on adding the first two hydrogen atoms than in all subsequent additions, even on splitting of the ring; but it must be added that no such difference occurs in other physical properties on addition of the first two hydrogen atoms to benzene, as, for instance, density, and molecular refraction.—W. H. H.

Thermodynamics (*Heat*). The investigation of the relations between heat and other forms of energy. These relations are governed by two fundamental laws. *See* THERMODYNAMICS, LAWS OF.

Thermodynamics, Laws of (*Heat*). The FIRST LAW states that if a quantity of heat be entirely converted into mechanical energy, the amount of such energy is a fixed quantity; and, *vice versa*, a given quantity of mechanical energy is convertible into a given fixed quantity of heat. In other words, the ratio of the quantity of heat to the quantity of mechanical energy is constant. This is algebraically expressed by the equation $W = J H$, in which J represents the Mechanical Equivalent of Heat (*q.v.*) The SECOND LAW cannot be so simply expressed. Lord Kelvin's statement of this law is as follows: "It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of surrounding bodies." Clausius' mode of expressing the law is: "It is impossible for a self-acting machine, unaided by any external agency, to convey heat from one body to another at a higher temperature."

Thermo-Electricity. It was discovered by Seebeck (in 1821) that if a circuit be formed by joining two dissimilar metal conductors together at their ends, and one junction be heated, a current will flow in the circuit. For example, let an iron wire and a copper wire be twisted together at their ends, and one junction be heated, a current will flow from the copper to the iron at the hot junction; we have what is termed a THERMO-ELECTRIC CURRENT, and the pair of metals form a THERMO-ELECTRIC COUPLE. For the sake of comparison, the E.M.F. produced by a couple made of each of the following metals respectively, with lead as the second metal, is given. The temperature difference between the hot and cold junctions is in each 1° C:

Bismuth . .	about	90	microvolts.
Nickel . .	„	22	„
German Silver .	„	12	„
Platinum . .	„	− ·9	„
Copper . .	„	− 1·36	„
Zinc . . .	„	− 2·3	„
Iron . . .	„	−17·5	„
Antimony . .	„	−23	„

This electromotive force is termed the THERMO-ELECTRIC POWER of the metal. The E.M.F. of a couple depends upon the temperatures of the junctions in a manner which may be expressed by the formula

$$E = a(T_2 - T_1) + b(T_2^2 - T_1^2),$$

where E is the E.M.F., T_2 and T_1 the temperatures of the junctions, and a and b coefficients depending on the metals employed. If the *mean* temperature of the two junctions attain a certain value, the E.M.F. vanishes: this temperature is termed the NEUTRAL TEMPERATURE, and is given by the equation

$$\frac{T_2 + T_1}{2} = -\frac{a}{2b} = T_n$$

From this equation it is easily seen that

$$a = -2b\,T_n$$

and from the first formula

$$E = 2b(T_2 - T_1)\left(\frac{T_2 + T_1}{2} - T_n\right)$$

Thus E vanishes when $T_2 = T_1$, and also if $\frac{1}{2}(T_2 + T_1) = T_n$. If one junction be kept at a constant temperature, the E.M.F. attains a maximum when the other is at the neutral point; while, if one be kept at the neutral point, the E.M.F. will gradually fall in amount as the other is heated, vanishing when the two junctions are at the same temperature, and becoming reversed if the second junction is heated above the neutral point. This phenomenon is termed THERMO-ELECTRIC INVERSION.

A thermo-electric couple supplies a very convenient method of measuring high temperature; for this purpose the wires are often platinum and a platinum-iridium alloy. The couple is connected in series with a high resistance galvanometer, the scale of which may be graduated to read directly in degrees. A number of couples are frequently connected in series in such a manner that the alternate junctions may be simultaneously exposed to a source of heat. Such an arrangement constitutes a THERMO-ELECTRIC PILE or THERMOPILE, and is commonly employed for the detection and measurement of radiant energy. In the RADIO-MICROMETER of Boys a single couple, forming part of a closed circuit, is suspended by a

delicate quartz fibre between the poles of a powerful magnet, such as is used in suspended coil galvanometers. Radiant energy falling on the junction produces an E.M.F., which sets up a current in the suspended circuit, which then acts in the same way as the coil of a galvanometer. This instrument is so delicate that it has enabled the radiant heat from a candle two miles away to be detected.

PELTIER EFFECT: Peltier found (1834) that a reversible thermal effect occurs when a current flows across a junction of two dissimilar metals, heat being liberated when the current flows in one direction, and absorbed when it flows in the other. The amount of heat liberated or absorbed in a given time is proportional to the current, and is perfectly distinct from the "Joule Effect" or production of heat, which depends upon the resistance of the conductor.

THOMSON EFFECT: Lord Kelvin (Sir William Thomson) found that if different parts of any given conductor in which a current is flowing are at different temperatures, there is, in general, an absorption or a liberation of heat. Heat is absorbed in an iron conductor if a current flow from a hot to a cold point; in copper the reverse is the case. If there be a small difference of temperature, $t_1—t_2$, between two adjacent points in the conductor, the heat developed in the part between these two points, when unit quantity of electricity flows from one to the other, is $\sigma\ (t_1—t_2)$. The coefficient σ is called the "Specific Heat of the electricity in the metal."

Thermo - Electric Power, etc. (*Elect.*) *See* THERMO-ELECTRICITY.

Thermometer (*Heat*). An instrument for the MEASUREMENT OF TEMPERATURE (*q.v.*)

——, **Electric** (*Heat*). *See* MEASUREMENT OF TEMPERATURE.

——, **Maximum and Minimum** (*Heat*). *See* MAXIMUM AND MINIMUM THERMOMETER.

——, **Mercurial** (*Heat*). *See* MEASUREMENT OF TEMPERATURE.

——, **Platinum** (*Heat*). *See* MEASUREMENT OF TEMPERATURE.

—— **Resistance** (*Heat*). *See* MEASUREMENT OF TEMPERATURE.

Thermometer Screen (*Meteorol.*) A box or case, perforated in order to allow the free circulation of air, used to protect a thermometer from the direct action of the sun's rays. The thermometer gives the true temperature of the air. The commonest pattern is Stevenson's Screen, with sides made of parallel shutters or louvers.

Thermometric Conductivity, Coefficient of (*Heat*). The diffusivity of a substance. *See* DIFFUSIVITY.

Thermometric Scales (*Heat*). *See* SCALE, THERMOMETRIC.

Thermopile (*Elect.*) *See* THERMO-ELECTRICITY.

Thermostat. An instrument for regulating temperature or for maintaining a uniform temperature.

Thicknessing (*Carp.*) Planing down wood to a required thickness. The operation is effected in large shops by a planing machine, which is furnished with two cutter blocks, the distance between which can be adjusted; the machine is termed a Thicknessing Machine.

Thicknessing Machine (*Carp., etc.*) *See* THICKNESSING.

Thick Spaces (*Typog.*) Spaces used for dividing words and cast three to an em of their own body. *See* TYPES.

Thimble (*Eng.*) A term often used for a cylindrical or conical socket; also for a conical mandrel used in forging rings, which are slid on in order to preserve the circular form while being hammered.

—— (*Plumb.*) A brass socket for attaching lead pipes to stoneware.

—— (*Pot.*) The smallest size of flower pot made, being 2 in. deep and 2 in. in diameter. The next size ($2\frac{1}{2}$ in. by $2\frac{1}{2}$ in.) is called "Thumbs."

Thin Fount (*Typog.*) Founts of type of which the lower case letters *a* to *z* measure in width less than twelve times the depth of their body are called thin founts.

Thinners (*Dec.*) Linseed oil and turpentine form the usual thinners of the house painter, these liquids being employed to thin the finely ground pigments to a consistency suitable for being applied to a surface by means of a brush. The oil serves to bind the particles of the pigment together, and the turpentine serves to further "thin" the mixture or render it more liquid. *See* LINSEED OIL *and* TURPENTINE. Although the thinners used by house painters almost universally are confined to linseed oil and turpentine, in no fixed proportions, it is recognised by the best authorities that they may be varied with advantage according to the nature of the pigment. Thus, when oxide of zinc (*q.v.*) or zinc white is employed, it is important to use very little turpentine with the addition of only refined boiled linseed oil. Some paint manufacturers who prepare special paints send them out in paste form with liquid thinners of exactly the proper composition ready to be added as the paint is mixed. This practice has much to recommend it, and is likely to increase.

Thinning Out *or* **Down** (*Eng.*) Bevelling the edges of boiler plates, etc., where they are to overlap at a joint.

Thin Plates and Films, Colours of (*Light*). When light falls on a thin plate of any transparent material, interference occurs between the light which is reflected at the front surface and that which is reflected at the back surface. In the case of a plate of uniform thickness the interference may be complete for light of one particular wave length; if this was the wave length of the incident light, then the interference will be a maximum, and the amount of light reflected will vanish. If the incident light was white, then one colour will be destroyed, and the resultant light will become coloured. If the thickness of the film varies, the colours which are destroyed will also vary, and different tints will be produced in the reflected light. NEWTON'S RINGS form a good example of these colours. A lens of small curvature is laid on a glass plate, and successive rings appear surrounding a central spot, which is dark when viewed by transmitted light. With mono-chromatic light the surrounding rings are alternately bright and dark; with white light they appear coloured. If the rings be viewed by transmitted light, the central spot is bright, and the positions of the bright and dark rings are interchanged, a bright one occurring where a dark one appeared by the reflected light, and *vice versa*.

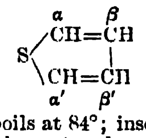
Thin Spaces (*Typog.*) Spaces used for dividing words and cast five to an em of their own body. *See* TYPES.

Thio- (*Chem.*) A prefix used in naming sulphur compounds. In most cases it indicates that in the compound bearing the prefix one or more sulphur atoms have replaced one or more oxygen atoms.

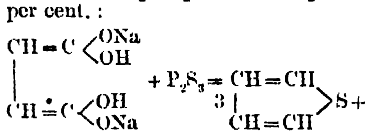
Carbonic acid	H_2CO_3	Thiocarbonic acid	H_2CS_3
Cyanic acid	HCNO	Thiocyanic acid	HCNS
Sulphuric acid	H_2SO_4	Thiosulphuric acid	$H_2S_2O_3$
Urea	$CO(NH_2)_2$	Thiourea	$CS(NH_2)_2$

Thiocyanates (*Chem.*) Another name for SULPHOCYANATES (*q.v.*)

Thionine (*Chem.*) Another name for LAUTH'S VIOLET (*q.v.*)

Thiophene (*Chem.*) 

A colourless liquid; boils at 84°; insoluble in water, soluble in benzene, ether, etc.; has faint smell resembling benzene. It is attacked by halogens more readily than benzene, even iodine forming substitution products with it in presence of mercuric oxide; the halogens first enter the α-position. Strong nitric acid oxidises thiophene, but if air charged with thiophene vapour is led into nitric acid, nitro compounds (mono- and di-) are formed. Forms a sulphonic acid when a dilute solution in light petroleum is shaken with concentrated sulphuric acid. Thiophene and its derivatives on treatment with a little isatin and some concentrated sulphuric acid give a deep blue colour—this is called the Indophenine reaction. Thiophene can be obtained by heating sodium succinate with phosphorus trisulphide—yield about 50 per cent.:



(Tautomeric form.)

It was first obtained from coal tar benzene, in which it occurs to the extent of about ½ per cent.; the benzene is shaken with concentrated sulphuric acid, the acid is diluted with water and distilled in steam, when nearly pure thiophene is obtained—the product is separated from water, dried, and redistilled. Thiophene is obtained in small quantity by passing acetylene through boiling sulphur.

Homologues of thiophene occur in coal tar; thus α-methylthiophene occurs in coal tar toluene. They can be obtained synthetically from diketones and γ-ketonic acids. Examples: (1) Phosphorus pentasulphide converts acetonyl acetone (*see* DIKETONES) into $\alpha\alpha'$-dimethylthiophene. (2) Phosphorus pentasulphide converts lævulinic acid into methylthiophene. *See* LÆVULINIC ACID. The homologues can also be obtained from the halogen substitution products of thiophene just as benzene homologues are obtained from benzene. On oxidation the homologues of thiophene yield thiophene carboxylic acids just as homologues of benzene yield benzene carboxylic acids.

Thiosulphates (*Chem.*) Salts of thiosulphuric acid $H_2S_2O_3$. This acid may be regarded as derived from sulphuric acid by replacement of an atom of oxygen by an atom of sulphur. The constitution of sulphuric acid is $\begin{smallmatrix}O\\O\end{smallmatrix}\!>S<\!\begin{smallmatrix}OH\\OH\end{smallmatrix}$ Thiosulphuric is regarded as derived from it by replacement of one of the hydroxyl oxygen atoms by a sulphur atom $\begin{smallmatrix}O\\O\end{smallmatrix}\!>S<\!\begin{smallmatrix}OH\\SH\end{smallmatrix}$ That it is a hydroxyl oxygen that is replaced is shown by several reactions of formation and decomposition of the thiosulphates, *e.g.*:

(1) A thiosulphate is formed when iodine acts on a normal sulphite in presence of a normal sulphide—

$$O_2S<\begin{smallmatrix}ONa\\Na\end{smallmatrix} + Na_2S + I_2 = O_2S<\begin{smallmatrix}ONa\\SNa\end{smallmatrix} + 2NaI.$$

$$O_2S<\begin{smallmatrix}ONa\\Na\end{smallmatrix} + C_2H_5SNa + I_2 = O_2S<\begin{smallmatrix}ONa\\SC_2H_5\end{smallmatrix} + 2NaI.$$

(2) When sodium ethyl thiosulphate is decomposed by a dilute acid mercaptan and sodium acid sulphate are formed—

$$O_2S<\begin{smallmatrix}ONa\\SC_2H_5\end{smallmatrix} + HOH = O_2S<\begin{smallmatrix}ONa\\OH\end{smallmatrix} + HSC_2H_5.$$

(3) Gentle warming of silver thiosulphate with water gives silver sulphide and sulphuric acid—

$$O_2S<\begin{smallmatrix}OAg\\SAg\end{smallmatrix} + HOH = O_2S<\begin{smallmatrix}OH\\OH\end{smallmatrix} + SAg_2$$

If the constitution of thiosulphuric acid is $O_2S<\begin{smallmatrix}OH\\SH\end{smallmatrix}$ isomerism should exist among the thiosulphates, and this is the case—

I. $O_2S<\begin{smallmatrix}ONa\\SK\end{smallmatrix}$	II. $O_2S<\begin{smallmatrix}OK\\SNa\end{smallmatrix}$
Melts at 62°.	Melts at 57°.
105·3 parts dissolve in 100 parts water at 15°; with ethyl bromide it gives $O_2S<\begin{smallmatrix}ONa\\SC_2H_5\end{smallmatrix}$	213·7 parts dissolve in 100 parts water at 15°; with ethyl bromide it gives $O_2S<\begin{smallmatrix}OK\\SC_2H_5\end{smallmatrix}$

Salt I. is prepared by neutralising sodium hydrogen sulphite with potassium carbonate, and acting on the product with ammonium pentasulphide; salt II. in a similar way from potassium hydrogen sulphite.

Third (*Music*). The interval between two notes occupying two degrees of the stave next but one to each other, as E, G. *See* INTERVALS *and* TEMPERAMENT.

Third Flute (*Music*). The flute in E♭. *See* MUSICAL INSTRUMENTS, *p.* 434.

Thistle (*Her.*) The flower and leaves of one of the *Carduus* family form the Emblem of Scotland. A very ancient order of knighthood is entitled the Most Noble and Ancient Order of the Thistle of Scotland.

Tholos (*Architect.*) Originally used to denote the roof of a circular building, but the term came to be applied to the circular building. *See* PELASGIC.

Thomson Effect (*Elect.*) If a current flow along a conductor whose temperature varies at different points, heat is absorbed at a given point, or is liberated at the same point, according to the direction of the current. In an unequally heated iron wire, heat is absorbed when the current flows from the hotter to the colder part of the wire; while with copper heat is absorbed when the current flows from the colder to the hotter part of the wire. A reversal of the current reverses the thermal effect in all cases. This effect is quite distinct from the heating effect which occurs in accordance with Joule's law (*q.v.*)

Thorax (*Zoology*). The anterior part of the trunk of an animal. It is protected by the ribs at the sides and by the sternum (breastbone) on the under (ventral) surface.

Thorium (*Chem.*) Th. Atomic weight 232·5. A rare metal belonging to Group IV. Series 12 in the Periodic System. It is a white metal; sp. gr. 11; it has not been melted; burns brightly when heated in oxygen; dissolves in nitric acid and aqua regia. Thorium occurs as silicate in thorite and orangeite, and as phosphate in monazite; it also occurs in a number of other minerals, but those mentioned are the chief source of the metal and its compounds. The metal is obtained by heating potassium thorium chloride $KCl.2ThCl_4$, with sodium under a layer of common salt in an iron cylinder with screw cover. There is some doubt as to whether thorium and its compounds are radioactive; according to some chemists, thorium prepared from uranium-free minerals is inactive. However, ordinary thorium and its compounds—for example, a Welsbach gas mantle—are radioactive: they give out the α, β, and γ rays (*see* RADIOACTIVITY), but the energy radiated as α-rays is about 22 times as much as that radiated by the β-rays, and it has been calculated that 1 gram of thorium emits about 70,000 α-particles per second, which is equivalent to 0·3 gram calories per year. Thorium and its compounds also yield an emanation which can be removed from them by merely drawing a current of air over the selected compound (usually the oxide); the emanation accompanies the air current; it is a gas which condenses between $-120°$ and $-155°$, and is unacted on chemically by any physical or chemical treatment, such as strongly heating it, treating it with acids and the like, but it decomposes spontaneously. The amount of the emanation is excessively small; there is present at any one time in 1 gram of thorium which is in a state of radioactive equilibrium not more than 5×10^{-14}cc. at the ordinary temperature and pressure. The thorium atom (or if not thorium some other unknown element which usually accompanies thorium), therefore, is unstable and decomposes; the stages of the decomposition so far as they are known may be represented thus:

Thorium

ThoriumX * — α-particle

Emanation† (a gas) — α-particle (1 or more)

EmanationX ‡ (a solid) — α-particle

Inactive substance

Active substance

α-particle — β-particle — ?

γ-rays

ThoriumX (ThX) can be obtained from thorium nitrate by precipitating the hydroxide with ammonia (*not* by caustic soda), filtering and evaporating the solution in a platinum dish—it is of course not visible or weighable. As thorium is undergoing decomposition, it is of interest to know how long a given mass would take to decompose completely: to give some idea of this, it has been calculated that of a given mass of thorium only 1 per cent. would remain at the end of 10^{10} years. COMPOUNDS: The oxide ThO_2 is the starting point for the preparation of the metal and its compounds. It is obtained, for instance, from thorite by evaporating it in finely powdered condition with hydrochloric acid, extracting the heated residue with water, removing lead by sulphuretted hydrogen, and precipitating the filtrate from the lead sulphide with ammonia. The very impure hydroxide is washed, dissolved in hydrochloric acid, and precipitated by oxalic acid. After washing, the oxalate is heated to convert it to oxide. The oxide, which still contains traces of other metals, is moistened with water, and heated with concentrated sulphuric acid in a platinum dish, when it forms the sulphate, which is dried, powdered, and dissolved in the minimum of water at 0°: on allowing the temperature to rise to 20°, the hydrate $Th(SO_4)_2 9H_2O$ separates out—this depends on the fact that the hydrate $Th(SO_4)_2 9H_2O$ is less soluble than any other hydrate up to 43°, and that its solubility increases rather rapidly above 20°. The process is repeated till a pure salt is obtained. Its solution is then precipitated by ammonia, and the hydroxide strongly heated to convert it into oxide. The oxide is a white powder which has not been melted. After it has been strongly heated, it is insoluble in acids except strong sulphuric acid. It is used in the preparation of the Welsbach mantle, and for this purpose it is prepared by heating the nitrate. *See* FLAME. The hydroxide $Th(OH)_4$ is obtained by precipitating any soluble thorium salt with ammonia: it is soluble in acids forming the corresponding salts. The chloride $ThCl_4$ is a white crystalline solid, somewhat deliquescent; crystallises from water with $8H_2O$; has a normal vapour density at 1050°. It is obtained by heating the metal in dry hydrogen chloride, or by heating a mixture of the oxide and carbon in a current of chlorine. The nitrate $Th(NO_3)_4$ is very soluble in water, and is obtained by dissolving the freshly precipitated hydroxide in nitric acid: it gives the oxide when heated. The sulphate $Th(SO_4)_2$ is obtained as described above, and is remarkable for the number of its hydrates and their stability. The hydrate $Th(SO_4)_2 9H_2O$ is the least soluble up to 43°, at which temperature it decomposes into $Th(SO_4)_2 4H_2O$, which diminishes in solubility from 18° to 100°, when it decomposes into $Th(SO_4)_2 2H_2O$. Over 45° the hydrate $Th(SO_4)_2 4H_2O$ is the least soluble. The carbide ThC_2 is a transparent crystalline solid, obtained by heating the oxide with sugar charcoal in the electric furnace: it is decomposed by water giving a number of hydrocarbons, among which are acetylene (47 per cent.), methane (29 per cent.), ethylene (6 per cent.), and, in addition to these, about 18 per cent. of hydrogen.

Thorne Composing Machines. *See* TYPE SETTING MACHINES.

Thorough Bass (*Music*). The continuous bass, bearing figures to show what harmony is to accompany it, in a composition. The term is often used

* Loses half its activity in four days. † Loses half its activity in one minute.
‡ Loses half its activity in eleven hours; cause of excited radioactivity; soluble in hydrochloric and sulphuric acids (the emanation is not soluble in these acids).

to denote any figured bass, whether *basso continuo* or not. Also as a term synonymous with harmony, as "the rules of thorough bass," meaning "the rules of harmony"; this, however, is not the real meaning of the term. For example of figured bass, *see* SCORE.

Thread (*Eng.*) *See* SCREW.

Thread Gait (*Lace Manufac.*) The available space between any two carriages in a lace machine.

Threading (*Lace Manufac.*) The operation of placing the brass bobbin properly into its carriage or shuttle, and threading the end of the material through the hole or guide.

Three Coat Work (*Plastering*). Plastering executed in three successive coats, viz. (1) Pricking-up Coat, (2) Floating Coat, (3) Setting Coat.

Three Colour Process. *See* PHOTO ENGRAVING *and* PHOTOGRAPHY IN COLOURS.

Three High Rolls *or* **Mill** (*Eng.*) A rolling mill with three rollers one above another. *Cf.* TWO HIGH.

Three Moments, Theorem of (*Mech. Eng.*) A theorem by which the bending moment at the points of support may be determined in the case of a "continuous" beam or girder, *i.e.* one resting on three (or more) supports. For a detailed discussion of this theorem, works on the Theory of Structures, etc., must be consulted.

Three Part Box (*Foundry*). A moulding box or flask in three separate parts; used in cases where a casting has to be made with a central portion which does not allow the easy withdrawal of the pattern.

Three Phase System (*Elect. Eng.*) A system of generating and distributing electric energy, which is of great value when power has to be transmitted over a considerable distance. An alternate current generator is used, which produces three alternating currents, differing in phase by one-third of a complete period, *i.e.* by 120°. It is only necessary to use three wires for the distribution of the three currents; the use of these three wires must, however, be carefully distinguished from that of the conductors in a three wire system (*q.v.*)

Three Quarter (*Bind.*) A book cover the back of which is of leather, extra wide, the corners covered with leather, and the sides with cloth or paper.

—— (*Paint.*) The term denotes a size of portraiture 30 in. long by 25 in. wide, the figure being shown to the hips. *Cf.* KIT-CAT.

Three Quarter Bat (*Build.*) Three-fourths of a brick used in the place of a closer and a header in a brick wall.

Three Square (*Eng.*) Three sided, or triangular in section.

Three Throw Crank (*Eng.*) Three cranks carried on one shaft, the angle between two consecutive cranks being 120°.

Three Throw Pump (*Eng.*) A pump with three barrels, the plungers or pistons being driven by a three throw crank (*q.v.*)

Three Wire System (*Elect. Eng.*) A system of electrical distribution, in which two dynamos are employed, and are connected to three distributing conductors. One of these, the NEUTRAL or BALANCING WIRE, is connected to the positive brush of one dynamo and the negative brush of the other; the remaining wires are connected to the two other brushes respectively. The lamps, etc., supplied by the system are connected to the neutral wire and one of the other wires, and so arranged that approximately equal numbers are connected to each of the two "outer" or principal conductors. The current in the neutral wire is then equal to the difference of the currents in the two other wires, and may be zero.

Threshold (*Build.*) The stone step of a doorway.

Thrice-marked Octave (*Music*). *See* PITCH.

Throat (*Eng., etc.*) (1) The opening at the top of a blast furnace. (2) A part of an object corresponding to the opening or neck of a bottle.

Throating (*Build.*) The groove cut on the underside of a skylight, transome of a frame, stone cills, etc. This groove serves to prevent the rain from running along the under surface by capillary attraction, and finding an entrance through crevices, especially in the case of skylights.

Throstle Frame (*Cotton Spinning, etc.*) A system of flyer spinning which is fast falling into disuse. It is being superseded by the ring frame (*q.v.*)

Throttle Valve (*Eng.*) A valve placed in the pipe which supplies steam (or gas) to an engine; the supply is controlled by opening or closing the throttle valve, which operation is effected in steam engines by the governor (*q.v.*)

Throttling (*Eng.*) Regulating the supply of steam (or gas, etc., in the case of a gas engine) by means of a throttle valve.

Through Stone (*Masonry*). A bonding stone going through the thickness of a wall.

Throw (*Eng.*) (1) An old term for a LATHE (*q.v.*) (2) The diameter of the circle described by the centre of a crank pin; it equals the stroke of the piston.

Throw of a Fault (*Geol.*) The amount of the vertical displacement produced in strata by a fault (*q.v.*)

Throw Off Impression (*Print.*) An arrangement by which the cylinder of a printing machine is raised clear of the forme, which may then travel beneath without an impression being made.

Thrust (*Eng.*) A pressure, particularly that exerted along the axis of a rod or a shaft.

Thrust Block *or* **Bearing** (*Eng.*) The bearing which takes the longitudinal thrust in a propeller shaft; it contains a number of grooves, in which corresponding rings or collars (the THRUST COLLARS) formed on the shaft rotate. The thrust is thus received directly by surfaces of metal, which are normal, or at right angles, to the force which they have to overcome, hence lateral motion of the shaft is prevented.

Thrust Collars (*Eng.*) *See* THRUST BLOCK.

Thrust Plane (*Geol.*) The plane of dislocation in a reversed fault (*q.v.*) Also termed a GLIDING PLANE.

Thrust Screw (*Eng.*) A screw placed in line with a rotating shaft or mandrel, with its end in contact with the end of the shaft: its use is to take any thrust in the shaft, and to provide a longitudinal adjustment for the latter. Used in some forms of drilling machine, lathe, etc.

Thuja occidentalis (*Botany*). A tincture used in pharmacy, made from the young shoots of the *Arbor vitæ* (*Coniferæ*).

Thumb (*Pot.*) *See* THIMBLE.

Thumb Lever Composing Stick (*Typog.*) So called because the slide is fixed by pressing down a lever.

Thumb Mould (*Join.*) A moulding used on the edge of tables.

Thumb Plane (*Join.*) Small planes, 3 or 4 in. long, used in working mouldings, rebates, etc., in situations where an ordinary plane cannot be used conveniently.

Thumb Screw (*Eng.*) A small screw with a head so formed that it can be turned by the thumb and finger.

Thumb Screw Composing Stick (*Typog.*) So called when the slide is fixed by means of a thumb screw. *See* COMPOSING STICK.

Thumper (*Music*). The level felted weight against which organ keys hit when they rise. Its duty is to keep the key level.

Thunder (*Meteorol.*) The noise corresponding to that produced by the passage of an electric spark. It is due to the sudden heating and consequent expansion and contraction of the air column. The rumbling noise is caused by numerous refractions and reflections from adjacent clouds and hills.

Thunderstorm (*Meteorol.*) Local progressive atmospheric disturbances occurring in most latitudes; accompanied by rain and electrical phenomena such as lightning.

Thurible. A CENSER (*q.v.*)

Thus (Frankincense *or* Olibanum). A resin which gives out a marked odour on being burnt, and is one of the main constituents of the mixture called incense, burnt in religious ceremonies. The name "incense" refers to the combustion which develops the odour. Thus is the dried exudation of certain resinous trees, and comes from Africa and Arabia. It has been known from very remote antiquity, and has been used for chewing as well as for fumigating. The name Olibanum is derived from the Hebrew word for milk (lebonah), and refers to the milky appearance of the sap before it hardens on exposure to the air. The Arabian and East African product is obtained from various species of *Boswellia*, while the West African olibanum, which comes mostly from Sierra Leone, is a product of *Daniellia thurifera*. Frankincense occurs in commerce in the form of pear-shaped "tears," always covered with a white dust. When this is rubbed off, the masses are seen to be either milky or clear and semi-transparent. The colour is a pale yellowish red, very faint in the best qualities. As regards constitution, it is a gum resin, containing about 33 per cent. of a gum said to be identical with gum arabic, and 56 per cent. of a resin which is separated from the gum by alcohol, in which the latter is insoluble. The remaining 9 per cent. or thereabouts consists of an essential oil easily obtained by distilling the frankincense with water or in a current of steam. This oil is sometimes quite colourless, but is usually somewhat yellow, and has the same smell as the burning incense, which therefore probably owes its odour to the volatilisation of unburnt oil. It is a matter of common knowledge that incense is burnt in partially closed vessels, not only for the convenience for swinging, but to restrict the access of atmospheric oxygen. The oil has a specific gravity of about 0·88, and is lævorotatory. It consists mainly of terpenes, and therefore boils at about 170° C., but its constitution is not accurately known. The oil was formerly largely used in medicine, and is still so to some extent, although it is not officinal. Frankincense and its oil are very similar to myrrh and the essential oil obtained from that resin. *See also* GUM THUS.

Thymol (*Botany*). An antiseptic substance obtained from the volatile oils of the plants *Thymus vulgaris*, *Monarda punctata*, *Carum copticum* (order, *Labiatæ*).

—— (*Chem.*)

$$CH_3.C\begin{matrix}\diagup CH-CH \diagdown \\ \diagdown CH-COH \diagup\end{matrix}C.CH(CH_3)_2$$ (3-methyl-6-isopropylphenol).

A colourless solid crystallising in large tables; melts at 44°; boils at 230°; slightly soluble in water (1 in 1500); soluble in alcohol and ether. It has a smell of thyme. It dissolves in caustic soda or potash, forming crystalline salts, which liberate thymol on treating them with an acid. Distillation with phosphorus pentasulphide converts it into cymene (*q.v.*) On oxidation with chromic acid it yields a quinone. When acted on by iodine in alkaline solution it yields a monoiodo derivative, a diodo derivative, or a diododiphenyl derivative according to the conditions of the experiment. The last of these substances contains 46 per cent. of iodine, and is used as an antiseptic under the name aristol; the only advantage it has over iodoform is that it has very little odour. Thymol occurs in oil of thyme, which may contain as much as 30 per cent. of it; it is obtained from this oil by shaking with caustic soda, separating the soda solution, and precipitating it with hydrochloric acid; the precipitate is crystallised from acetic acid. Thymol is a stronger antiseptic than phenol and is used in medicine as an antiseptic; its slight solubility in water is perhaps against its general use.

Thyrsus (*Archæol.*, *Art*). An attribute of Dionysus (Bacchus) and his votaries. It consists generally of a staff tipped with an ornament like a pine cone, sometimes wreathed with ivy or vine branches, but various forms are recorded.

Tiara. (1) A headdress somewhat like a turban, worn by the ancient Persians. The tiara is still the ceremonial headdress of the kings of Persia. (2) The Pope's triple crown, a tapering cylindrical diadem surrounded by three crowns, and surmounted by a mound and cross. (3) A coronet and ornament for the head in the form of a coronet.

Tibia (*Archæol.*) A variety of flagolet or flute, made either single or double.

—— (*Zool.*) In a mammal one of the two bones forming that portion of the leg (hind limb) lying between the knee and the foot. The term is also applied to a part of one of the appendages in certain invertebrates.

Tidal Basin (*Civil Eng.*) A dock which communicates through lock gates with tidal water. Vessels can enter as soon as the tide reaches the level of the water in the basin. *See* DOCKS.

Tides (*Astron.*) Alterations which occur in the depth of a large body of water, owing to the attraction exerted by the sun and moon. Water drawn from one place (where it is low tide) is accumulated at another (where it is high tide). This phenomenon is progressive, the tides following the relative motions of the earth, moon, and sun. The theory of the tides is long and complex. It is given in full in works on Gravitational Astronomy. *See* PRIMING OF THE TIDES.

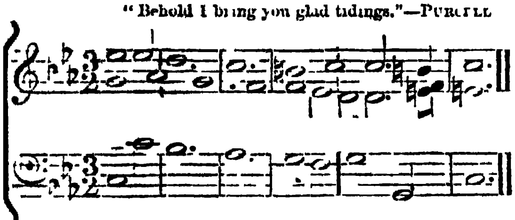
Tie (*Eng.*) A member of a structure which exerts a tensile force between two other parts. It is usually a thin rod, which is theoretically capable of being replaced by a chain or cord.

—— (*Music*). *See* BIND. To what is stated there may be added the following: Mr. Franklin Taylor points out that occasionally in pianoforte music the second note is actually repeated in such a way that the note is rapidly and closely restruck before the damper has quite fallen, so that there is no actual silence between the two sounds. The following is an example:

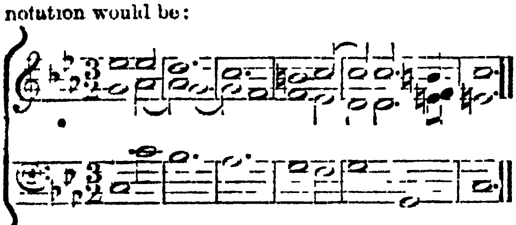
Valse Op. 34, No. 1.—CHOPIN.

In older music ties were less used, the notes being written as follows:

"Behold I bring you glad tidings."—PURCELL.



In modern music ties are invariably used when a note is sustained in two bars. The above in modern notation would be:



—— (*Silk Manufac.*) The term applied to an arrangement of threads in plain weaving, *e.g.* "satin" tie, "twill" tie, etc.

Tie Beam. *See* ROOFS.

Tie Bolt (*Eng.*) A bolt serving as a tie (*q.v.*)

Tier, Teir, *or* **Rangs** (*Lace Manufac.*) A row of carriages in working position.

Tierce (*Music*). A metal organ stop sounding the third in the second octave, *i.e.* the seventeenth, of the foundation stop. It is seldom found in modern organs, owing to the difficulties in introducing it under the equal temperament tuning. The tierce now forms one of the ranks in the mixtures (*q.v.*)

Tierce de Picardie (*Music*). The third in a major chord which closes a piece written in the minor key. The older composers always used this chord in minor key compositions for the final chord, or else omitted the third altogether. An example is given from Purcell's anthem *under* TIE.

Tiercerons (*Architect.*) *See* RIB AND PANEL VAULT.

Tie Rod (*Eng.*) *See* TIE.

Tiger Nut (*Botany*). The tuberous rhizomes of *Cyperus esculentus* (order, *Cyperaceæ*), rich in starch and oil, are used as an article of food in Southern Europe, where they are known under the various names of "Chufa," "Amande de terre," "Souchet comestible." They are exported from the Gold Coast under the name of tiger nuts.

Tightening Pulley (*Eng.*) A pulley used for tightening or taking up the slack in a belt, driving cord, or chain. The pulley can be moved and clamped in any position within certain limits.

Tile (*Build.*) (1) Generally a thin piece of baked clay finished according to the purposes for which it is intended, *e.g.* covering roofs, floors, walls, or for lining furnaces. Tiles are also made of porcelain, glass, marble, metal, etc. Roofing tiles are made in various forms, but the most usual form is the pantile (*q.v.*) Tiles are also made for use in specific parts of a roof, *e.g.* crest tiles, ridge tiles, etc. (2) The name given to a short earthenware pipe used in making a drain.

Tile Ore (*Min.*) A red or reddish brown variety of CUPRITE (*q.v.*) containing a certain percentage of iron.

Till (*Geol.*) A name given in Scotland to BOULDER CLAY—*i.e.* a glacial material enclosing boulders and angular fragments of numerous older rocks.

Tilt, Tilting. Charging with the lance or spear.

Tilt Hammer (*Met.*) An early form of power hammer. It may be compared to a large hand hammer, pivoted at one end of its handle, and gradually raised by a cam or projection on a wheel revolving immediately underneath the shaft. When the cam passed a certain point, the hammer fell suddenly, striking a heavy blow. It was much used in puddling mills and forges, but is now obsolete.

Tilting Fillet (*Carp. and Join.*) *See* SPROCKET PIECES.

Tilting Helmet (*Arm.*) A heavy helmet used in the fifteenth and sixteenth centuries at the joust or tilt (*q.v.*) The lumière or opening for vision was high up so that the wearer could only see his opponent when bending forward in the saddle for the course. *Cf.* TOURNEY HELMET.

Timber. *See* WOODS.

Timber Measurement. Timber in bulk is measured in units termed STANDARDS. A standard of pine is 720 ft. of 11 in. by 3 in.; boards are measured by the superficial foot, reckoning the unit thickness as 1 in.; large logs by the cubic foot; smaller stuff by the linear foot or "foot run."

Timber Rack. A place for the storage of timber, either while drying or afterwards when ready for use. In the former case the timber is always laid horizontally; in the latter it may be stored in a vertical position.

Timber Washer (*Build., etc.*) A metal washer (*q.v.*) used to prevent the heads and nuts of bolts employed in woodwork from injuring the fibre of the wood.

Timbre (*Music*). The quality of a sound, due to the form of the sound waves. A good quality of tone is comparatively rich in upper partials (*q.v.*), and the existence of these depends on the wave form. Rounded forms give a soft quality, whilst a more or less piercing quality results from angular ones. *See* HARMONICS; SOUND.

Time. All measurements of time are based on the natural units, the Day and the Year. As these are not invariable periods, MEAN TIME has been introduced. The scientific unit of time is the SECOND, which is the $\frac{1}{86400}$ part of a mean solar day. *See* MEAN SOLAR DAY, MEAN SUN, SOLAR TIME, *and* WEIGHTS AND MEASURES.

—— (*Music*). (1) The speed at which a musical composition is performed is called the time or tempo (*q.v.*) (2) The division of musical phrases into measures of equal lengths, having especial regard to the accents; the rhythm, as common time; triple time. These divisions are indicated by time signatures (*q.v.*) There are two kinds of time: (*a*) Common time; (*b*) triple time. In common time the accents occur on alternate beats, whilst in triple time they occur once in every three beats. Common time is sometimes divided into duple and quadruple time, respectively two and four beats in a bar. Both common and triple time are subdivided into simple and compound times. Compound time is formed by combining two, three, or four bars of triple time into one bar: two or four bars making compound common time, three bars making compound triple time. These are all set out in full *under* TIME SIGNATURE. Other kinds of time consist of combinations of common and triple time, *e.g.* quintuple time is formed by combining one bar of common time with a bar of triple time, thus:

or a bar of triple time with a bar of common, thus:

See TIME SIGNATURE.

Time, Beating of (*Music*). The signs by which a conductor leads a performance. These signs are generally made with a short stick, called a baton, and should be made decidedly and by a wrist movement. Flourishing the baton and all other unnecessary movements only worry both performers and audience. The following diagrams show the movement of the baton in beating different measures of time:

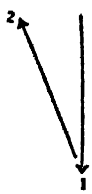


FIG. 1.—TWO BEATS IN A BAR.

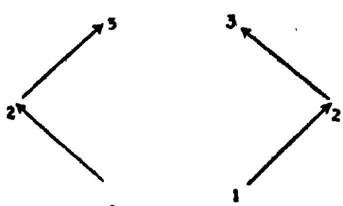


FIG. 2.—THREE BEATS IN A BAR.

The former of these is most general, and it has the advantage of being less seen by the audience than the latter, although equally visible to the performers. The latter, however, is generally used when there are performers behind the conductor. In quick triple time the beats are often given thus:

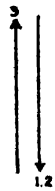


FIG. 3.—THREE BEATS IN A BAR (quick).

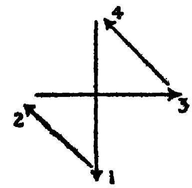


FIG. 4.—FOUR BEATS IN A BAR.

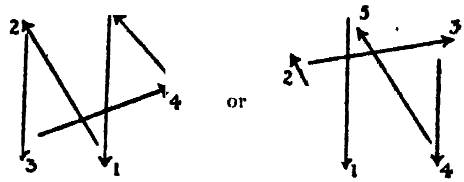


FIG. 5.—FIVE BEATS IN A BAR.

according to the place of the second accent. *See* TIME.

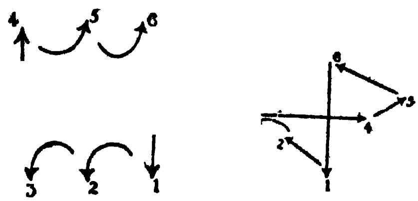


FIG. 6.—SIX BEATS IN A BAR.

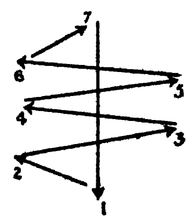


FIG. 7.—SEVEN BEATS IN A BAR.

Eight beats are given by duplicating each of the four beats, and twelve by trebling them, thus:

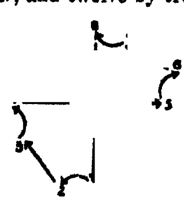
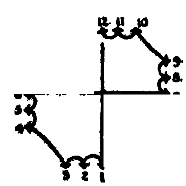


FIG. 8.—EIGHT BEATS.



TWELVE BEATS.

Nine beats are given as in fig. 9.

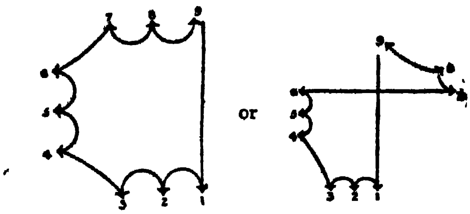


FIG. 9. NINE BEATS IN A BAR.

Timepiece. *See* WATCHES AND CLOCKS.

Time Sheets. Papers on which are recorded the hours which men have worked each day (or week) and the actual piece of work on which they were engaged. From the time sheets are compiled the wages sheets for the payment of the men, and the cost in labour of each job

Time Signature (*Music*). Signs placed at the commencement of a piece, immediately after the key signature, to indicate the rhythm in which it is written. Sometimes a change of time signature occurs during a movement, as in the following:

LISZT.

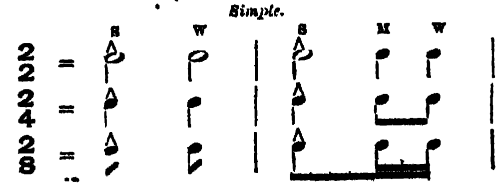
thus showing a temporary change of accent. With the exception of the signs ₵ and C, all the time signatures are denoted by figures. These figures are fractions of the semibreve (the standard note of measurement), the top figure (numerator) showing the number of beats, and the bottom figure (denominator) the kind of note of which each beat consists, *e.g.* $\frac{3}{4}$ = three-fourths of a semibreve, *i.e.* three crotchets in a bar. The signs ₵ and C are not the capital C denoting common time, but are derived from a circle. In ancient music the circle ○ denoted perfect or triple time, and the broken circle, ₵ or C, imperfect or common time. The barred ₵ denotes four minims in a bar, and is known as *Alla breve*. The C now denotes four crotchets or two minims in a bar, and is known as *Alla capella*. Both signs, however, are rapidly disappearing, and giving place to figures. The following table shows the signatures now generally in use, with their explanations and the strong, medium, and weak accents. It must be remembered that the signature shows the number of *beats* in a bar, not the number of notes:

TABLE OF TIME SIGNATURES.

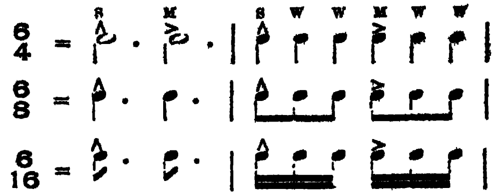
(1) *Common Time.*

(*a*) DUPLE MEASURE.

Simple.

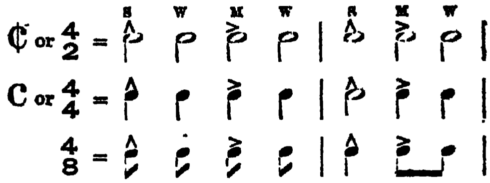


Compound.

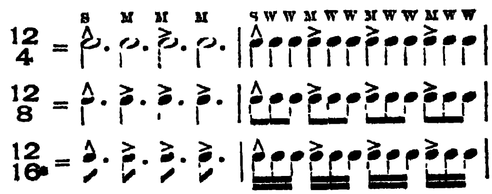


(*b*) QUADRUPLE MEASURE.

Simple.

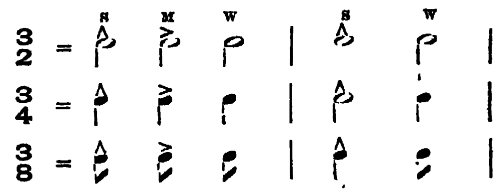


Compound.

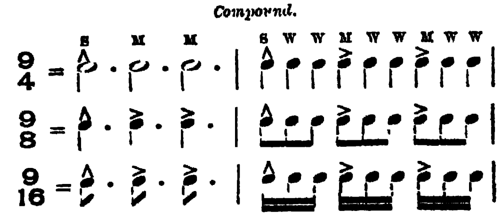


(2) *Triple Time.*

Simple.



Compound.



Other signatures may occasionally be met with, an example being given under TIME showing five crotchets in a bar. That shown above, $\frac{6}{4}$ ($\frac{3}{2}$), indicates that there are six crotchets in a bar, but having the accents on alternate crotchets—that is, a subdivision of triple time, $\frac{3}{2}$, not compound duple where the accents are on the first and fourth. In Handel's "Suite de Piece" the following combined time signatures occur in some editions:

but the same result is obtained by either writing both parts in C time and marking the groups as triplets, or by writing both in $\frac{24}{16}$ time and dotting every bass note. *See also* TIME.

Timidamente; Timore, Con; Timoroso (*Music*). Timidly; with hesitation.

Timpani, Tympani (*Music*). Kettledrums. *See* MUSICAL INSTRUMENTS, *p.* 444.

Tin (*Chem.*) Sn. Atomic weight, 119. A white metal; melts at 232°; specific gravity 7·29: very malleable, but becomes brittle at 200°. It crystallises easily: for example, by melting it, allowing part to solidify, and pouring away the still liquid part, rhombic prisms are obtained. The sound emitted by a bar of tin when it is bent is ascribed to the fracture of crystals in the interior of the bar. When tin is strongly cooled it changes to a grey powder of sp. gr. 6: this change is quickest at $-48°$. The transition point for the two forms of tin is 20°. At 20°, and even for many degrees below, the rate of change of white to grey tin is very slow: but it is greatly accelerated by putting the metal into a solution of ammonium stannic chloride $(NH_4)_2SnCl_6$, as white tin has a higher solution pressure in this than has grey tin, so that the change once started will proceed, white tin throwing out grey tin from solution. Tin is not oxidised in air at the ordinary temperature, but it is easily oxidised on heating it in air or oxygen; the dioxide is formed on complete oxidation. The action of acids is as follows: Hot strong hydrochloric acid dissolves tin somewhat readily, forming stannous chloride and evolving hydrogen. Warm dilute sulphuric acid gives stannous or stannic sulphate, according as the tin or acid is in excess, and hydrogen is evolved; but with the hot concentrated acid sulphur dioxide, sulphuretted hydrogen, and sulphur are obtained in place of hydrogen. The strongest nitric acid has no action; when sufficiently diluted it forms metastannic acid, $H_{10}Sn_5O_{15}$, probably owing to hydrolysis of previously formed stannic nitrate; the dilute acid forms stannous and ammonium nitrates. Aqua regia forms stannic chloride. Hot strong caustic soda or potash forms sodium or potassium stannate with evolution of hydrogen. Tin forms many important alloys with other metals, *e.g.* bronze, pewter, solder, gun-metal, bell-metal, Britannia metal (*see these*). It also amalgamates readily with mercury, and this amalgam was at one time largely used in making mirrors; but it is not used for this purpose now. Tin is extensively employed in the manufacture of tinplate, which is sheet iron coated with tin; the form of iron employed is rolled wrought iron or mild steel. The surface of the iron to be tinned must be very clean; it is cleaned by immersing the sheet in dilute sulphuric acid, and then polishing it with sand and water. The tinning is effected by dipping the sheet in melted tin, the surface of which is protected from air by melted fat. In reality the tin alloys with the iron, and the alloy is far less readily acted on by water than iron itself. Tin occurs chiefly as the dioxide SnO_2 (tinstone: cassiterite) (*q.v.*) To obtain tin the ore is crushed and washed with water, the stream of water carrying away much of the lighter impurity (sp. gr. tin ore = 6·5; sp. gr. rock = 2·7). The washed ore is dried and roasted; the roasting process converts sulphides to oxides, the sulphur escaping as dioxide, and it removes arsenic in the form of the volatile arsenious oxide, which is condensed in suitable chambers. If the ore contain much copper, the roasting is so conducted as to form as much copper sulphate as possible, which can be extracted with water, and the copper obtained from the solution: if it contain tungsten, this is removed by roasting with carbonate of soda in a reverberatory furnace, when a soluble sodium tungstate is formed, and is extracted with water. The ore is once more washed, mixed with powdered anthracite, and reduced by heating it in a reverberatory furnace. The crude tin so obtained is purified by placing it in bar form on the hearth of a reverberatory furnace and heating it gradually, so that the easily fusible tin separates, leaving behind a higher melting alloy of tin and other metals which are not entirely removed in the preceding processes. This easier fused product is received in an iron vessel over a fire to keep the tin melted, and poles of wet wood are plunged into it ("poling"), the object being to agitate the metal, which is then exposed to air, and the last traces of oxidisable metals removed as oxides which form a scum on the surface of the tin. When cast the product is known as block tin: when heated to the temperature at which it becomes brittle and then broken up it forms grain tin.

Tincal (*Min.*) *See* BORAX.

Tin Compounds (*Chem.*) Tin forms two oxides—stannous oxide, SnO, and stannic oxide, SnO_2. These oxides function both as basic and acid oxides. From the first are derived the stannous salts SnX_2, and the stannites M_2SnO_2; from the second are derived the stannic salts SnX_4, and the stannates M_2SnO_3. X stands for a monovalent acid radical and M stands for a monovalent metal or positive compound radical, *e.g.* NH_4. STANNOUS OXIDE is a dark crystalline powder. When heated in air it is oxidised, but not completely, to the dioxide; it is insoluble in water, but soluble in acids, forming stannous salts. When caustic potash solution, in slight excess, is added to a solution of stannous chloride, a precipitate of STANNOUS HYDROXIDE, $Sn(OH)_2$, is obtained, which when filtered and washed yields stannous oxide on boiling with water containing only a little caustic potash. The white precipitate of hydroxide obtained above dissolves in excess of caustic potash (or soda), and the resulting solution contains a stannite, K_2SnO_2. The STANNITES are reducing agents. Thus they give a black precipitate of hypobismuthous oxide Bi_2O_2 with a solution of a bismuth salt,

they reduce diazonium chlorides to hydrocarbons ($C_6H_5N_2Cl$ to C_6H_6), and they reduce nitro compounds to azo compounds ($C_6H_5NO_2$ to $C_6H_5N_2C_6H_5$). STANNOUS CHLORIDE, $SnCl_2$, is a white solid; melts at 250°; boils at 606°. Its vapour density corresponds to a mixture of Sn_2Cl_4 and $SnCl_2$ molecules except at very high temperatures, when it corresponds to that required by $SnCl_2$. Ordinarily the salt is met with crystallised in small prisms containing two molecules water of crystallisation, $SnCl_2 2H_2O$. These crystals are soluble in a little water, but excess of water hydrolyses the salt, and a basic chloride, insoluble in water, but soluble in acids, is precipitated $(Sn.OH.Cl)_2H_2O$; they are also soluble in alcohol. A solution of stannous chloride absorbs oxygen from the air, giving the basic chloride just mentioned. It is much used as a reducing agent, *e.g.* it reduces silver, mercury, gold, and platinum salts to the metal, ferric to ferrous salts, nitro compounds to amines. When stannous chloride solution containing stannic chloride is used to reduce a gold solution, a precipitate known as purple of cassius is produced which contains gold and stannic acid; but what form the union between the two takes cannot be regarded as settled. Stannous chloride unites with alkaline chlorides to form double salts such as $(NH_4)_2SnCl_4$. Stannous chloride is used under the name of tin salt in dyeing and calico printing. The anhydrous salt can be prepared by heating tin in hydrochloric acid gas, and the crystallised salt $SnCl_2 2H_2O$ by dissolving tin in hydrochloric acid and evaporating the solution. STANNOUS SULPHIDE, SnS, is obtained as a grey crystalline solid by direct union of its elements or as as a brownish black precipitate when sulphuretted hydrogen is passed into a solution of a stannous salt. It is soluble in alkaline polysulphides forming sulphostannates, *e.g.* $(NH_4)_2S_2 + SnS = (NH_4)_2SnS_3$; it is also soluble in strong hydrochloric acid. STANNIC OXIDE is a white powder which can be obtained in crystals like the natural product, but small, by heating in a current of hydrochloric acid gas; on heating it changes colour, becoming reddish brown at a high temperature: melting point unknown; insoluble in water or acids except sulphuric acid which dissolves it, but the stannic oxide is precipitated unchanged on addition of water. It is reduced to the metal by strongly heating it in hydrogen, or with carbon (*see* TIN), or easily by fused potassium cyanide. When fused with caustic soda or potash it forms stannates. Stannic oxide is obtained by roasting tin in air or by heating any of its hydrates. Under the name of putty powder it is used for polishing purposes, in making white glass and in enamelling (rendering the enamel opaque). STANNIC HYDROXIDES: The normal hydroxide $Sn(OH)_4$ (β-stannic acid) possesses both feeble basic and acid properties—it dissolves in dilute acids to form stannic salts and in alkalis to form stannates. It is very unstable, easily losing water on heating. This hydroxide is obtained by adding a solution of a neutral salt such as sodium sulphate or ammonium nitrate to a solution of stannic chloride—the chloride is hydrolysed by the water and the colloidal solution of the hydroxide is precipitated by the neutral salt. Another hydroxide, H_2SnO_3 (α-stannic acid), is obtained by adding calcium carbonate to a solution of stannic chloride or by adding hydrochloric acid to a solution of an alkaline stannate. Its properties are similar to those of the normal hydroxide. A third hydroxide known as metastannic acid $(H_2SnO_3)^n$ is obtained as a white solid by the action of strong nitric acid on tin; it has feeble acid properties, forming salts with alkalis. On heating it gives stannic oxide. It is insoluble in strong acids but combines with them, giving compounds which dissolve in pure water. SODIUM STANNATE, Na_2SnO_3 obtained as mentioned above, crystallises well from water with three molecules water of crystallisation. It is used in calico printing under the name preparing salts. STANNIC CHLORIDE, $SnCl_4$, is a colourless liquid; boils at 114°; has a normal vapour density; fumes in air. With water it unites to form several distinct hydrates—*e.g.* $SnCl_4 3H_2O$, $SnCl_4 5H_2O$, $SnCl_4 8H_2O$—all crystalline solids. It dissolves in much water with partial hydrolysis—this is shown by the fact that on distilling the solution unchanged stannic chloride passes over with the steam while stannic hydroxide separates from the boiling solution; the hydroxide also separates on allowing a dilute solution to stand. It unites with hydrochloric acid and water in nearly theoretical proportions to form the well crystallised acid $H_2SnCl_6 . 6H_2O$ (chlorostannic acids); a number of double chlorides may be regarded as salts of this acid—*e.g.* ammonium stannic chloride $(NH_4)_2SnCl_6$, which is formed by mixing solutions of the two chlorides and crystallising; it is soluble in three times its weight of water at 15°; it is used as a mordant in dyeing under the name of pink salt (*see also* TIN.) A similar compound is formed by aniline $(C_6H_5NH_3)_2SnCl_6$. Stannic chloride is easily prepared by distilling tin in a retort in a current of dry chlorine and redistilling the product over tin filings. The chloride in the form of its pentahydrate (oxymuriate of tin) is much used as a mordant in dyeing. STANNIC SULPHIDE, SnS_2 (mosaic gold) forms golden yellow leaves when obtained in the dry way, or a dull yellow powder containing hydrated stannic oxide when prepared in the wet way. The crystalline form is not soluble in hot concentrated hydrochloric acid, but the amorphous form is: both forms dissolve in alkaline sulphides forming sulphostannates,

$$SnS_2 \times (NH_4)_2S = (NH_4)_2SnS_3;$$

both forms dissolve in alkalis, forming a mixture of stannate and sulphostannate. The crystalline form is obtained by subliming a mixture of tin filings, sulphur, and ammonium chloride, when the latter alone sublimes and leaves the stannic sulphide behind; it cannot be obtained by heating sulphur and tin together, for so much heat is evolved when the reaction is started that stannic sulphide is resolved into stannous sulphide and sulphur. In the wet way sulphuretted hydrogen is passed into a solution of stannic chloride. The crystalline form is used to imitate gold. When an alloy of tin and sodium is heated with methyl iodide a colourless oil is obtained. Analysis and a vapour density determination show that it has the formula $Sn(CH_3)_4$. This tin tetramethyl yields, on treating it with iodine, tin trimethyl iodide, $Sn(CH_3)_3I$, which is also a liquid. When tin trimethyl iodide is acted on by caustic soda it yields a hydroxide, tin trimethyl hydroxide, $Sn(CH)_3OH$, which is a crystalline solid and behaves like a strong alkali. An optically active tin compound has been prepared from tin trimethyl iodide by the following series of reactions:

$$2Sn(CH_3)_3I + Zn(C_2H_5)_2 = 2Sn(CH_3)_3(C_2H_5) + ZnI$$

$$Sn(CH_3)_3(C_2H_5) + I_2 = Sn(CH_3)_2(C_2H_5).I + CH_3I$$

$$2\,Sn(CH_3)_2(C_2H_5)I + Zn(C_3H_7)_2 = 2Sn(CH_3)_2(C_2H_5)(C_3H_7) + ZnI_2$$

$$Sn(CH_3)_2(C_2H_5)(C_3H_7) + I_2 \quad Sn(CH_3)(C_2H_5)(C_3H_7)I + CH_3I$$

The tin methylethylpropyl iodide is an oil which yields a salt of α-camphorsulphonic acid on treating it with silver α-camphorsulphonate. The tin methylethylpropyl-α-camphorsulphonate is a crystalline solid showing dextrorotation. The lævorotatory salt is not obtained on concentrating the mother liquor probably owing to the great ease with which it racemises. Many other organic tin compounds are known.

Tincture (*Her.*) The heraldic term for colour. *See* HERALDRY.

Tine. The prong of a fork; sometimes the fork itself.

Tinning (*Met.*) Coating iron (or steel) with metallic tin. The plates are cleaned and dipped into baths of molten tin, which forms a thin and uniform coating over the iron, and serves to protect the latter from oxidation and to give it a bright surface.

—— (*Plumb.*) Covering the parts to be joined with a thin coating of solder.

Tin Plates (*Met.*) Thin sheets of soft iron or mild steel, which have been coated with tin by a process of dipping. The sheets are first cleaned by pickling (*q.v.*) and are then placed in a vessel or "bath" of melted tin for some time, then removed, redipped, and allowed to drain. The tin which solidifies along the lower edge is removed by the further application of heat, and the plates are then ready for sorting. This process is termed TINNING. *See also* TIN.

Tin Pyrites (*Min.*) Also termed STANNINE and BELL METAL ORE. A sulphide of tin, copper, and iron, usually with some zinc. Crystallises in the cubic system. Colour variable; grey when pure. It forms an ore of both tin and copper in localities where it occurs in sufficient abundance. Found in Cornwall and in the Erzgebirge.

Tinstone (*Min.*) A common name for CASSITERITE (*q.v.*)

Tint (*Dec.*) A colour which has been lightened by the addition of white. The word, like shade (*q.v.*) and hue (*q.v.*), is often very loosely employed. Any number of tints can be obtained from one colour by adding different proportions of white.

Tirasse (*Music*). The coupler. *See* MUSICAL INSTRUMENTS, *pp.* 442, 443.

Tire. A TYRE (*q.v.*)

T-Iron (*Eng., etc.*) Wrought iron in section the shape of the letter T.

Titan Crane (*Eng.*) An overhanging crane used in laying large blocks in the construction of breakwaters, etc. A massive truck running on rails laid along the top of the completed part of the breakwater carries a vertical axis or pivot. On this turns a large horizontal girder frame, carrying the engine and boiler at one end. Along this frame runs a travelling crane. The whole girder frame can be rotated, giving, in the case of some modern Titans, a radius of action up to 160 feet.

Titanic Acid (*Min.*) *See* ANASTASE, BROOKITE, *and* RUTILE.

Titanic Steel (*Met.*) Steel containing a small amount of the rare metal TITANIUM. It is used to some extent for cutting tools.

Titaniferous Iron Ores (*Min.*) *See* ILMENITE.

Titanium (*Chem.*) Ti. Atomic weight 48·1. Not known in pure condition. It has been obtained containing 2 per cent. of carbon by heating an intimate mixture of carbon and titanium dioxide in a carbon crucible in the electric furnace (1000 ampères and 60 volts), removing the crude metal so produced, and heating it again, mixed with titanium dioxide at the same temperature. So obtained it is a very hard white metal: melting point unknown, but over 1680°; sp. gr. 4·9; when heated in oxygen it burns, forming the dioxide; in the form of powder it burns in nitrogen at 800°, forming the nitride; heated in steam to low redness it burns and the metal becomes white hot; it burns in chlorine at 325°, forming the tetrachloride $TiCl_4$; cold dilute sulphuric acid and boiling concentrated hydrochloric acid give a violet solution and evolve hydrogen, the former quickly, the latter slowly; nitric acid slowly oxidises the metal to the dioxide. Titanuim occurs as the dioxide (*see* ANATASE, BROOKITE, RUTILE); as titanate of iron (*see* ILMENITE); as calcium titanium silicate (*see* SPHENE). Titanium belongs to the carbon group in the periodic system (*q.v.*) A few of its principal compounds are: Titanium dioxide, TiO_2, is a white powder; when heated it becomes yellow then brown; melts in the oxyhydrogen flame; insoluble in water and acids except hot concentrated sulphuric acid, with which it forms a basic sulphate. On fusion with alkalis it forms titanates. It is also known in three different crystalline forms, of which one, the natural rutile, is isomorphous with tin dioxide; this form can be obtained by heating the artificial dioxide to a white heat with borax. The dioxide can be prepared by decomposing the tetrachloride with water, neutralising with ammonia, evaporating to dryness and strongly heating the residue; or powdered rutile is fused with potassium carbonate in a platinum dish and the powdered melt extracted with dilute hydrofluoric acid; water is added and the whole is boiled and filtered hot. Potassium titanofluoride, $K_2TiF_6H_2O$, crystallises out and is purified by recrystallisation. A solution of the pure salt is precipitated with ammonia, and the titanic hydroxide filtered, washed, and strongly heated gives the dioxide. Hydroxides corresponding to the silicic acids can be obtained—viz. orthotitanic acid, H_4TiO_4, by decomposing the tetrachloride with aqueous ammonia, and metatitanic acid, H_2TiO_3, by boiling a hydrochloric acid solution of the preceding compound—they are weak acids. The titanates, *e.g.* K_2TiO_3, are obtained as mentioned under the dioxide. Titanium tetrachloride, $TiCl_4$, is a colourles liquid; boils at 136°; fumes in air; it is decomposed by water, the chlorine atoms being replaced on cautious addition of water one by one till a solution of orthotitanic acid in hydrochloric acid is obtained. Like stannic chloride it forms double chlorides with the chlorides of the alkali metals. It is obtained by passing dry chlorine over a heated mixture of the dioxide and carbon. No normal nitrate is known. A sesquisulphate, $Ti_2(SO_4)_3$, is obtained when the metal dissolves in sulphuric acid—it forms a violet solution and is oxidised by nitric acid to the normal sulphate $Ti(SO_4)_2$. Various nitrides have been obtained; the compound of composition TiN is obtained in bronze coloured masses when the dioxide is heated in nitrogen in the electric furnace (300 to 350 ampères and 70 volts)—it is hard enough to scratch diamond. A carbide is known. Titanium cyanonitride, $Ti(CN)_2Ti_3N_2$, is often found in blast furnaces—its formation is due to the use of iron ores which contain titanium dioxide.

Title, Title Page (*Print.*, *Bind.*) Usually the first page of a work, giving its name and the names of the author and publisher.

Titration (*Chem.*) *See* VOLUMETRIC ANALYSIS.

Tl (*Chem.*) The symbol for THALLIUM (*q.v.*)

Toad's Eye Tin (*Min.*) *See* CASSITERITE.

Tobacco (*Botany*). The dried leaves of *Nicotiana tabacum* (order, *Solanaceæ*) is the chief source of tobacco, but other species of *Nicotiana* are used. LATAKIA is furnished by *N. rustica*. *See* NICOTINE.

Tobine (*Silk Manufac.*) An extra warp, working independently of the ground warp, making stripe or figure, flushing or floating over several picks.

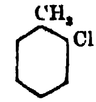
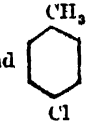
Tobin's Tube (*Hygiene*). A ventilator consisting of a vertical shaft rising to a height of about 6 ft. above the floor of a room. The air enters through a perforated grating at the floor level, and, after passing up the tube, ascends a few feet before mixing with the air of the room. The shaft should be detachable from the wall to facilitate cleansing, as it quickly becomes lined with dust and soot. *See* VENTILATION (*under* SANITATION).

Toga (*Archæol.*) The chief outer garment of the ancient Romans; a flowing wrap or mantle more voluminous than the Greek himation (*q.v.*) It was usually a woollen fabric and white in colour, but that worn by the Magistrates and the children of the nobility, *Toga prætexta*; had a deep purple border; the *Trabea* worn by the Knights (*equites*), Augurs, etc., was ornamented with purple stripes. *Toga picta*, worn by Consuls and other high officials, was adorned with stars. The toga was worn so as to leave the right arm of the wearer free. The right to wear it was exclusively the privilege of the Roman citizen. The *Toga virilis* was assumed by youths on attaining the age of fourteen. *Cf.* STOLA *and* PALLIUM.

Toggle Joint (*Eng.*, *etc.*) A combination of levers by means of which great pressure can be applied. Two rods are hinged together so as to make an obtuse angle with each other; one of these rods is attached to a fixed support or pivot, the other to the mechanism to which the pressure is to be applied. Force is applied at the junction of the two rods in such a manner as to tend to straighten the combination, *i.e.* to bring the two rods into line with each other; as the rods are brought gradually into line with each other, a great and increasing pressure is exerted at the ends. The combination is used in certain forms of press in which a great pressure but only a small amount of movement is required.

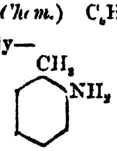
Toilet Soaps. Soaps usually of superior quality made for toilet purposes from a stock or base of ordinary hard soap, and usually moulded and scented. The stock is frequently a cold process soap, but white curd soap, cocoanut oil and rosin soaps are also used. The base is cut up into small pieces and remelted, perfume is then introduced, and in the cheaper grades the cakes of soap are simply moulded from pieces cut from the frame. In most toilet soaps, however, the process of milling is carried out, *i.e.* the soap is passed between rollers, whence it comes in fine ribbons, which are then perfumed and afterwards pressed with great force through a milling machine, from which the soap comes in the shape of a long firm bar. This is cut into pieces, which are at once moulded. The large variety of names given to toilet soaps depends principally upon the perfumes used or the colouring.

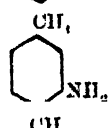
Token (*Print.*) Ten quires or half a ream of paper is a pressman's token.

Toluene (*Chem.*) $C_6H_5.CH_3$ (methyl benzene). A colourless liquid, boils at 110°, not miscible with water, smells like benzene, burns with a smoky flame. Induction sparks convert it into acetylene and hydrogen. Forms substitution products with bromine and chlorine: (*a*) when the halogen acts on boiling toluene in sunlight substitution occurs in the side chain and with chlorine; for example, benzyl chloride $C_6H_5CH_2Cl$, benzal chloride $C_6H_5CHCl_2$, and benzotrichloride $C_6H_5CCl_3$, are formed according to the amount of chlorine passed in; (*b*) when the halogens act in the absence of sunlight substitution occurs in the nucleus, ortho- and para-halogen substitution products being formed, *e.g.*  and ; (*c*) in presence of a halogen carrier bromine enters the nucleus entirely, but chlorine enters partly into the nucleus and partly into the side chain when the toluene is boiling and exposed to sunlight. On nitration with a mixture of nitric and sulphuric acids (10 parts toluene and 10·5 and 17·5 parts ordinary concentrated nitric and sulphuric acids) below 20° a mixture of nitrotoluenes is obtained (*o*—63 per cent., *m*—2 per cent., *p*—35 per cent.) After separating, washing, and drying, it is distilled under reduced pressure till 10 per cent. has passed over—the distillate is the pure ortho-compound, and the para-compound crystallises out from the residue, and can be purified by pressing and crystallisation. With sulphuric acid it yields a mixture of ortho- and para-sulphonic acids. In carbon disulphide solution toluene unites with chromyl dichloride (also in carbon disulphide solution) to form an addition product which is decomposed by water, forming benzaldehyde (Etard's reaction). Toluene is oxidised to benzoic acid by boiling with dilute nitric or chromic acids. It is reduced by heating with fuming hydriodic acid to hexahydrotoluene. Toluene is formed as a product of the dry distillation of many different substances, *e.g.* balsam of tolu (whence the name toluene), dragon's blood, wood, and coal. It is obtained on the large scale by the fractional distillation of coal tar (*see* GAS MANUFACTURE). In the laboratory it can be prepared by Fittig's reaction (*q.v.*), and by Friedel and Craft's reaction (*q.v.*)

Toluene, Toluol. *See* COAL TAR DISTILLATION.

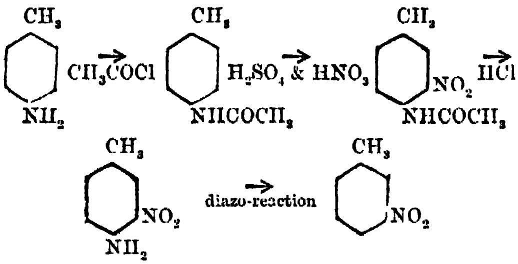
Toluidines (*Chem.*) $C_6H_4<\begin{matrix}NH_2\\CH_3\end{matrix}$ There are three of these, namely—

Orthotoluidine,  A colourless liquid, boils at 197°.

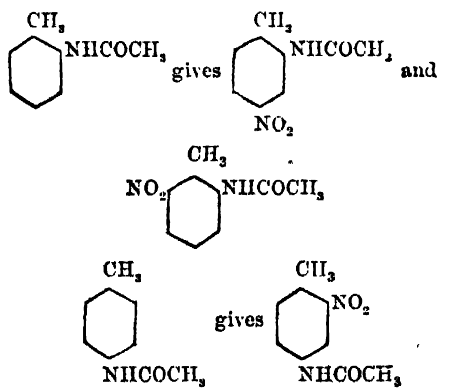
Metatoluidine,  A colourless liquid, boils at 199°.

Paratoluidine,  Shining white plates, melts at 45°, boils at 198°.

They are all obtained by reduction of the corresponding nitrotoluenes. (For the ortho- and paranitrotoluenes, *see* TOLUENE.) Metanitrotoluene is obtained by converting paratoluidine into paraacettoluidine by the action of acetyl chloride, nitrating the toluidide, hydrolysing, and then diazotising :



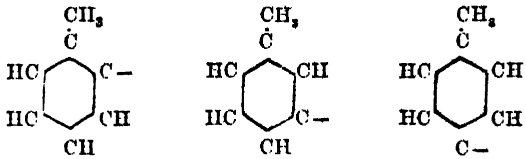
When the crude mixture of ortho-, meta-, and paranitrotoluenes (*see* TOLUENE) is reduced directly, the mixture of the three toluidines is technically known as "aniline for red" (*see* PARAROSANILINE). For some purposes the same mixture of the three is separated by partial neutralisation with oxalic or sulphuric acid and crystallisation, the orthotoluidine salts being the more soluble. The ortho- and paratoluidines are very important on account of their application in making dyes (*see* PARAROSANILINE *and* ROSANILINE). Orthotoluidine is somewhat volatile in steam; its solution in sulphuric acid is coloured blue by chromic acid; bleaching powder solution and hydrochloric acid give a violet colour; it is a weaker base than paratoluidine; it easily forms an acetyl derivative, which on oxidation with potassium permanganate gives orthoacetylaminobenzoic acid; on nitration or sulphonation the substituent takes the ortho position to the acetylamino group. Paratoluidine does not give the chromic acid and bleaching powder reactions; it readily forms an acetyl derivative, which is oxidised and substituted like the ortho-compound. When nitration of either compound is effected in presence of sulphuric acid, the nitro group enters into positions adjacent or para- to the methyl group, thus—



The toluidines undergo the diazo-reactions (*q.v.*) like aniline.

Toluylene Red (*Chem.*) *See* NEUTRAL RED.

Tolyl (*Chem.*) A name given to the residue remaining after taking away one hydrogen atom from the benzene nucleus of toluene. *E.g.*



Orthotolyl-　　Metatolyl-　　Paratolyl-.

These groups only exist in combination.

Tommy (*Eng.*) A small lever for inserting in a hole in the head of a screw, etc., to serve as a handle by which the screw may be turned.

—— (*Print.*) A small pointed steel rod used for regulating bolt headed set screws in a printing machine.

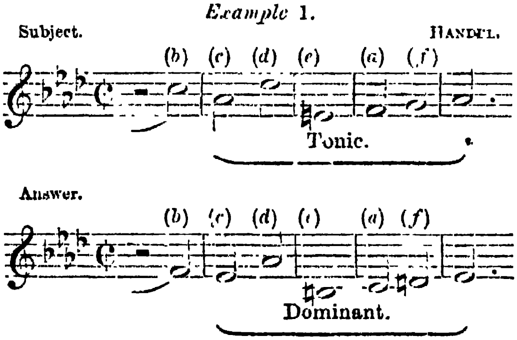
Tommy Hole (*Eng.*) The hole in which a tommy (*q.v.*) is inserted.

Ton. *See* WEIGHTS AND MEASURES.

Tonal Fugue (*Music*). A fugue that has the answer not in strict imitation, but modified in order to avoid a departure from the key tonality. *Cf.* REAL FUGUE.

EXAMPLE OF TONAL FUGUE.

Example 1.



Briefly stated it may be said that this modification is accomplished by having:

(1) The Tonic and Dominant when appearing prominently in the Subject answered respectively by Dominant and Tonic. *See* Example 1 (*a*) (*b*).

(2) The Mediant, Subdominant, and Submediant of the Tonic key answered by the corresponding notes of the Dominant key. *See* Example 1 (*c*) (*d*).

(3) That part of the subject which belongs to the Tonic key answered by the corresponding part of the Dominant key and *vice versa*. *See* Examples 1 and 2.

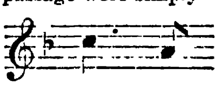
(4) Prominent intervals of a dissonant character, as *e.g.* the Diminished Seventh, etc., should be reproduced in the answer. *See* Example 1 (*e*), Example 2 (*c*).

5. The Supertonic of the Tonic key, sometimes answered by the Supertonic of the Dominant key, sometimes by the Dominant itself. Its duty in the Subject, *i.e.* whether it is the second of the Tonic key or the fifth of a Dominant key, must be carefully observed and accordingly answered. Example 1 (*f*) shows the second of the tonic answered by the second of Dominant, whilst Example 2 (*a*) (*b*) shows both

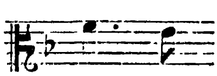
cases of the supertonic, and also further illustrations of the above rules :

Example 2.

It may be noticed that Cherubini in the second bar of Example 2 answers the Dominant by the Tonic, but treats the notes between C and A as auxiliary notes as if the passage were simply



answered by



hence the Subdominant (B) is not answered by the fourth of the Dominant (F), but by E, and the figure at the beginning of the bar left unaltered. Many exceptions to these rules may be found in the works of the great composers, but it will be observed that the exceptions are fully justified by the preservation of the character of the fugue. *See also* FUGUE, TONIC SOL-FA, *p.* 778 b.

Tonality (*Paint.*) The system of tones or colour scheme of a picture. *Cf.* CHIAROSCURO.

Tone (*Chromatics and Painting*). (1) The brightness or luminosity of a colour. (2) A quality of colour : a tint or shade. (3) The effect produced in a picture by the management of light and shade. *See* CHIAROSCURO.

—— (*Music*). (1) The interval between two sounds bearing the vibration ratio 8 : 9 as C.D., or 9 : 10 as D.E., the former being called a major tone, the latter a minor tone. A tone represents the larger steps of the scale, the smaller steps being called semitones (half-tones). *See* SCALE. (2) The quality of a sound, its timbre ; hence there is full, thin, reedy, woody, nasal tone, etc. (3) The Gregorian modes, as the 6th tone, etc.

—— (*Photo.*) The colour of a finished photograph. In some processes this is due to chemical action supplementary to producing and fixing the picture, *e.g.* the reddish hue of ordinary silver prints is altered to a more agreeable tone by means of a solution of which the principal agent is chloride of gold.

Tone (*Sound*). A single sound of definite pitch. An ordinary musical NOTE is composed of one principal tone, the FUNDAMENTAL TONE, accompanied by others, the overtones (*q.v.*)

Tones, Combination (*Sound*). *See* COMBINATION TONES.

Tonga (*Botany*). A medicinal preparation made from *Epipremnum mirabile* (*Aroideæ*) and *Premna Taitensis* (*Verbenaceæ*). Used as a specific for neuralgia.

Tongs. A form of tool used in a great variety of trades for holding objects which cannot be held in the hand. Tongs generally consist of two levers of the first kind hinged together at a point close to the jaws, *e.g.* blacksmith's tongs, crucible tongs, etc., or two levers of the third kind, connected by a spring or a hinge at the end opposite to the jaws.

Tongue (*Carp. and Join.*) (1) A projection to fit a groove. (2) A thin slip of wood, straight or cross grained, which fits into grooves ploughed in the edges of two boards which it is required to join together edge to edge.

Tongueing (*Carp., etc.*) Joining boards by means of a TONGUE (*q.v.*)

Tongue Joint (*Carp.*) A joint made by means of a TONGUE (*q.v.*)

—— (*Eng.*) A welded joint in which one piece has a V-shaped slit, the other being bevelled off so as to fit into the first.

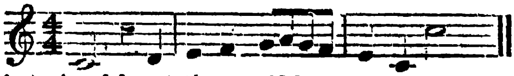
Tonic (*Music*). The technical name of the 1st degree of the scale ; the keynote.

Tonic Major (*Music*). The major scale having the same Tonic as the minor, but a different signature, as C minor, C major. *See* KEY SIGNATURE.

Tonic Minor (*Music*). The minor scale having the same Tonic as the major, but a different signature, as G major, G. minor. *Cf.* RELATIVE MINOR.

Tonic Sol-fa (*Music*). A system of musical notation, founded on a method of teaching singing by a Norwich lady, Miss Elizabeth Glover, and advanced by the late Mr. John Curwen. This system first attracted public notice in the middle of the nineteenth century, and, in order to give permanence to the system, the Tonic Sol-fa College was founded in 1869, and was incorporated in 1875. The tonic sol-fa system is adopted in a great number of elementary schools, and amongst its chief principles may be mentioned the "Movable Do" or keynote relationship—hence the word tonic, the presenting of music by letters instead of notes, with its accompanying method of indicating time duration and the teaching by mental effect and not by absolute pitch. The scales are presented in separate columns on a chart called a modulator, the scale of C being in the centre column, and the scales with flats on the left and those with sharps on the right. The tonic sol-fa method lays great emphasis on teaching from mental effect and of fixing the scale tones by chordal teaching, *i.e.* by firmly implanting the key tone and then building up in succession the notes d, m, s ; s, t, r ; and, lastly, f, l, d to complete the scale, and it is in this that the modulator is of great use. It has indeed been said that the modulator is the backbone of the system. In the centre column the major scale is shown in capital syllables Doh, Ray, Me, Fah, Soh, Lah, Te, Doh'. The melodic minor mode (scale) consists of the syllables Lah_1, Te_1, Doh, Ray, Me, Ba (pronounced Bay), Se, Lah. It will be noticed that chromatic flats are expressed by altering the vowel sound into a,

e.g. ra, ta (pronounced raw, taw), etc., and chromatic sharps have the vowel sound changed into e, *e.g.* de, fe (pronounced dee, fee), etc. Exceptions to this manner of naming occur in the following cases: Doh flat is du, fa flat is fu, me sharp is my, and te sharp is ty. The pulse (beat) always occupies the same amount of space in a composition, not as is found in the staff notation, *e.g.*

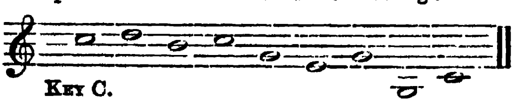


in tonic sol-fa notation would be:

KEY C.

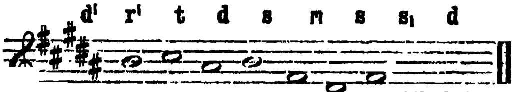
{|d :— | :r |m :f |s.l:s.f|m :d |d' :—||

It will be seen from this example that a line, —, indicates a prolonged sound, whilst a rest is indicated by a blank space. The longer upright line shows the strong pulse, the shorter upright line the medium pulse (middle of the measure), whilst the other pulses are shown by a colon. A single dot shows a pulse divided into halves, a comma into quarters, and a comma turned to the right into thirds. Doh (d) always stands for the keynote; it is therefore necessary to state the pitch of Doh at the beginning, *e.g.* key C, key F, etc. In the minor mode the key is expressed thus: Key E♭, *L* is *C*, signifying the key of C minor. When a modulation or transition of one or more removes occurs, the new key is shown, and attention called to the new tones on the right if to a sharp key, *i.e.* to the right on the modulator, thus: Key G......... A. t. m. This is called a transition of two removes (to a sharp key). If the transition is to a flat key, *i.e.* to the left on the modulator, the new tones are placed on the left, thus: Key A .... d. f. G.; or Key B .... s, d, f, D, *L* is *B*. These are respectively called a transition of two, and of three removes to a flat key. The pitch of sounds is taken from middle C (*q.v.*) to the B above according to the key; and from this note to the leading note, t. above the letters are unmarked. The octave or replicate above is written thus: d', r', m', etc., and the next octave d², r², m², etc. The octave or replicate below the unmarked octave is written d_1, r_1, m_1, etc., and the octave below this d_2, r_2, m_2, etc. The following example will show this manner of writing:



KEY C.

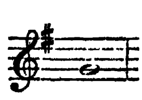
d' r' t d s m s s_1 d



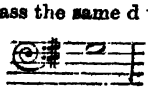
KEY B.

d r t_1 d s_1 m_1 s_1 s_2 d_1

In order to avoid unnecessary octave marks, it is customary to write tenor and bass parts an octave higher than they are—hence if d in the soprano represented



in the tenor and bass the same d would represent



The following example shows the "exposition" of Bach's Fugue in G minor in score and in tonic sol-fa notation:

Fugue No. 16.—"Das Wohltemperirte Klavier."

J. S. BACH.

KEY B♭. *Lah is G.* M. 80.

S. | : | :
A. | .m_1 :f_1 .l_1 |se_1 :l_1
T. | : | :
B. | : | :

F.t.

| : | .l_1 :^{d}f .l_1
| .t_2 ,d_1 :r_1 .d_1 t_2 |d_1 :$^l{}_2r_1$
| : | :
| : | :

| se_1 :l_1 | .t_1 ,d :r .d ,t_1
| .m ,r_1 :d_1 .r_1 ,m_1 |f_1 .r_1 :t_2 .se_1
| : | :
| : | :

| d .r ,m :f .m ,r |m .f ,s :l .s ,f
| l_1 :– .t_1 |d .t_1 :d .r
| : | :
| : | :

f.B♭.

| ^{s}r :d |t_1 .m ,r :d .r ,m
| $^m t_1$ .l_1 ,se_1 :l_1 .re_1 |m_1 .t :– .l_1 ,se_1
| : | :
| .m_1 :f_1 .l_2 |se_2 :l_2

F.t.

| f .r :t_1 .se |l :
| l_1 :se_1 .t_1 |m :
| : | .l_1 :^{d}f .l_1
| .t_2 ,d_1 :r_1 .d_1 ,t_2 |d_1 :$^l{}_2r_1$

| .$^{fe}t_1$:m .d |l_1 :se_1 .t_1 |– .l_1
| : | : |
| se_1 :l_1 | .t_1 ,d :r .d ,t_1 |d
| .m_1 ,r_1 :d_1 .r_1 ,m_1 |f_1 .r_1 :t_2 ,se_1 |l_1

The Tonic Sol-fa College is situated in Finsbury Square, London, and consists of a president (Mr. John Spencer Curwen, M.R.A.M.), two treasurers, secretary, and a council composed of six handworkers, nine clerks and other assistants in businesses, six masters engaged in commercial pursuits, six school teachers, nine professional musicians, six fellows of the College, three ministers, three engaged in literary, scientific, or artistic pursuits, and six honorary members. Its objects are to issue certificates, grant prizes, correct exercises, deliver lectures and lessons, and for the educational improvement of the teaching of the method. W. W.

Toning (*Photo.*) Altering the colour of a print by the partial substitution of gold, platinum or some other metal for the silver of the image, or by forming a compound with it which imparts a more pleasing colour to the photograph.

Tonne. *See* WEIGHTS AND MEASURES.

Tonquin Bean (*Botany*). The fragrant seeds of *Dipteryx odorata* (order, *Leguminosæ*) are used either in the form of a powder or as an extract in perfumery.

Tool. A general name applied in trades and arts to an implement used in or by hand, as opposed to a machine; also to the actual cutting or operating portion used in conjunction with certain machines, *e.g.* the actual cutting implement or "tool" used in a slide rest lathe or planing machine.

—— (*Dec.*) A small brush used by painters and decorators, especially one for painting window sashes.

Tool Box (*Carp., Eng., etc.*) (1) A box for storing tools. (2) The part of a machine tool by which the cutting tool is actually held.

Tooled (*Bind.*) The term applied to the cover of a book that has been ornamented by means of heated tools, etc. *See* BLIND TOOLING *and* TOOLING.

—— (*Build.*) The term applied to stonework in which the tool marks on the surface are parallel, and extend across the whole width of the stone. The external surface of masonry is often finished in this manner.

Tool Holder. A CUTTER BAR (*q.v.*)

Tooling (*Arts*). Skilled work accomplished by means of a tool, especially carving.

—— (*Bind.*) The ornament effected on the cover of a book by means of heated tools, etc., either in "blind" lines (*see* BLIND TOOLING) or in gold. *See also* BOOKBINDING.

Tool Post (*Eng.*) A simple form of tool holder or tool box used in small lathes; it consists of a projection from the upper part of the slide rest (*q.v.*) having a slot in which the shank of the tool is placed, and a set screw which holds the tool firmly in place.

Tool Smith (*Eng.*) A workman who forges and tempers the metal cutting tools used in an engineering shop.

Toothed Core Disks (*Elect. Eng.*) Disks of soft sheet iron, in the circumference of which are notches which form a series of parallel grooves in armature, etc., when built up. In these grooves the conductors forming the windings are placed.

Toothed Wheels. *See* GEAR WHEELS, *etc.*

Toothing (*Build.*) The projecting bricks left at the end of a wall, in order to form a bond for a second wall which is to be built on to the former.

Toothing (*Carp. and Join.*) Roughing the surface of wide pieces of wood that are to be glued together, to enable the surface to hold the glue and produce a strong joint.

Tooth Ornament (*Architect.*) The characteristic ornament of the Early English style, generally used in hollow mouldings. It is also known as the DOG TOOTH ornament.

TOOTH ORNAMENT.

Top (*Woollen Manufac.*) *See* COMBING.

Top and Bottom Tools (*Eng.*) Swages (*q.v.*) used in shaping forgings which cannot be correctly finished by the hammer alone.

Topaz (*Min.*) A fluo-silicate of aluminium, $[Al(O,F_2)]AlSiO_4$, orthorhombic; in attached or embedded crystals of yellow, grey, or blue tints, sometimes colourless. Hardness = 8. Most of the pink topaz is produced by the slow heating of the yellow varieties. Good specimens are much used in jewellery. From several localities in Cornwall. Beautiful blue crystals from Banffshire and Aberdeenshire, the Mourne Mountains, Siberia, Ceylon, Brazil, etc. *See also* PRECIOUS STONES.

Topazolite (*Min.*) A transparent greenish garnet. *See* PRECIOUS STONES.

Top Card (*Eng.*) An indicator diagram (*q.v.*) taken from the upper end of a cylinder, or from the end nearest to the crank.

Top Face (*Moulding*). The surface of a casting which is uppermost in the mould.

Top Iron (*Carp., etc.*) The upper or non-cutting portion of the double plane iron, used in the larger planes, such as the trying jack and smoothing planes. It serves to stiffen the cutting iron and to deflect and break the shaving as it is produced by the former.

Töpler Pump. *See* AIR PUMPS.

Top Part (*Foundry*). The upper part of a moulding box or of a mould.

Topping. Taking off the points of those teeth of a saw which project too far.

Top Rail (*Carp. and Join.*) The highest rail in any kind of framing.

Top Rake. The slope of the upper surface of a tool immediately behind the cutting edge.

Toque (*Cost.*) A silk or velvet cap without a brim or with a very narrow brim, generally adorned with a plume. Worn extensively in the sixteenth and seventeenth centuries by both men and women, and at a later period in France. A conical headdress, richly ornamented, worn by the Doge of Venice.

Torbanite (*Min.*) A hydro-carbon mineral found at Torbane Hill, in Scotland, used in gas making on account of the large volume of gas it yields. Of historic interest as having given rise to a famous lawsuit to determine if it were "coal" or not.

Torbernite (*Min.*) A hydrous uranium and copper phosphate, $CuO . 2UO_3 . P_2O_5 . 8H_2O$, tetragonal; in tubular crystals of grass green colour. The crystals easily cleave into thin laminæ, hence the mineral is sometimes called Uranmica; from its composition it is also known as Copper Uranite. It contains about 60 per cent. of uranic oxide, and about 15 per cent. of phosphoric acid. From Devon and Cornwall; Saxony, Bohemia.

Torching (*Build.*) Plastering the underside of tiles on a roof, when fixed on battens.

Tornadoes (*Meteorol.*) Low pressure areas of intense energy but of limited extent. They are associated with very strong winds, and capable of doing an immense amount of damage.

Torque (*Archæol.*) A convolute metal ornament forming a collar or a bracelet. Such an ornament was worn by the Gauls round the neck and by the Anglo-Saxons on the arms.

—— (*Phys., Eng., etc.*) *See* TURNING MOMENT.

Torricellian Vacuum (*Phys.*) The vacuum above the mercury in a mercurial barometer.

Torridonian Rocks (*Geol.*) *See* PRE-CAMBRIAN ROCKS.

Torrid Zone (*Astron.*) *See* TROPICS.

Torsion. Twisting, or the effect of twisting; the term is applied especially in physics and engineering to the twisting of a piece of a material by a couple. *See* TORSION, ELASTICITY OF.

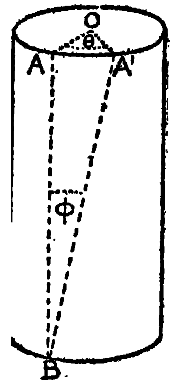
Torsional Pendulum (*Phys.*) If a heavy mass, suspended from an elastic fibre, be twisted through a small angle, and then set free, it will perform a series of simple harmonic oscillations about its position of rest. If K be the moment of inertia (*q.v.*) of the solid about an axis coinciding with the direction of the suspending fibre, and C be the restoring couple brought into play by the fibre when the mass is turned through a unit angle; then T, the time of vibration, is given by the formula

$$T = 2\pi\sqrt{\frac{K}{C}}$$

Torsional Stress. A twisting stress, or stress produced by the application of a couple (*q.v.*)

Torsion Balance (*Phys.*) An instrument for the investigation of the laws of electric and magnetic forces. The charged bodies (or poles) are at the ends of a horizontal rod, suspended by a fibre of silk, a fine wire, etc. An electric (or magnetic) force applied to the end turns the rod through an angle, and the magnitude of the force is proportional to the angle through which the top of the fibre must be turned in order to bring the rod back to the original position. In order to measure this angle, the top of the suspending fibre is attached to a graduated head, which can be turned through any required angle. An instrument on a similar principle was used by Cavendish (1797-8), in his experiments on the density of the earth; two leaden balls, 2 in. in diameter, were fixed at the ends of a rod 6 ft. long, suspended by a copper wire about 40 in. long; the attracting masses were two leaden spheres 12 in. in diameter, which could be placed nearer to, or farther from, the small spheres, thereby setting up a displacement due to the attraction between the large and small masses. The amount of this attraction was deduced from the time of vibration of the suspended system. This experiment has been repeated with a greatly improved form of apparatus by Boys (1895), the attracted masses being suspended by a fine quartz fibre.

Torsion, Elasticity of (*Phys., Eng., etc.*) If one end of a thin tube be rigidly fixed and the other end be twisted by a couple (*q.v.*) then the stress produced in the tube is of the nature of a SHEAR (*q.v.*) In the figure, the lower end of the tube is supposed to be fixed, and the upper end twisted until the line originally at O A is turned into the position O A', or through an angle θ, which is termed the ANGLE OF TORSION. Then the line B A is twisted into the position B A', or through an angle ϕ. The shear is then equal to this angle. If the actual amount of tangential force applied per unit area to the upper end of the tube be q, then we have



Coefficient of Elasticity of

$$\text{Torsion} \quad \frac{q}{\phi}.$$

This Coefficient is also termed the SIMPLE RIGIDITY. *See also* SHEAR.

In the case of a solid round bar (such as a shaft) the calculation of the coefficient depends upon dividing up the bar into imaginary concentric tubes, each of infinitesimal thickness, and then effecting a summation of the results by the Integral Calculus. This is one of the most important cases in practice: if l be the length of the shaft, r the radius, θ the angle of torsion, and T the applied couple by which the shaft is twisted, then we get the result

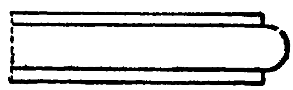
$$T = \frac{\pi r^4 \theta}{2l} C$$

That is, the Angle of Torsion is proportional to the couple which is applied, and inversely proportional to the fourth power of the radius of the shaft. Hence a small increase in diameter means a very large increase in the power of the shaft to resist torsion; if we double the diameter, we increase the resistance which the shaft offers to torsion to an amount which is sixteen times its former value.

The Simple Rigidity of some common materials is approximately:

Steel . .	8·2	10^{11}	dynes per sq. cm.
Wrought Iron	7·7	10^{11}	,, ,,
Brass . .	3·8	10^{11}	,, ,,
Quartz Fibre..	2·9	10^{11}	,, ,,

Torus (*Architect.*) A large convex moulding principally used in classical architecture.



TORUS.

Tossing (*Met.*) Oxidation of the impurities present in tin by lifting the fluid metal in ladles and pouring it back into the containing vessel; by this means the metal is exposed to the action of the air.

Tosto (*Music*). Rather. It is the equivalent of Quasi (*q.v.*)

Total Characteristic Curve (*Elect. Eng.*) *See* DYNAMO.

Total Eclipse (*Astron.*) *See* ECLIPSE, SOLAR.

Total Heat of Steam. The amount of heat necessary to raise unit mass of water from the freezing point to the temperature at which it is evaporated, and then to turn it all into steam at constant pressure. Using the pound as unit of mass and degree Fahrenheit as unit of temperature, the total heat of steam at t°F. is given by the formula

$$H = 1091{\cdot}7 + {\cdot}305\,(t^\circ - 32^\circ)$$

Using the gram and Centigrade degrees, this becomes

$$H = 606{\cdot}5 + {\cdot}305t$$

These are Regnault's values; but modern research suggests that the value

$$H = 596 + \cdot 399t$$

is probably more correct.

Total Internal Reflection (*Light*). If a ray travelling in one medium strike the surface separating that medium from one less dense, it will not emerge from the denser medium if the angle of incidence exceed a certain value. If the angle of incidence, i, be such that $\sin i = \mu$, the index of refraction from the first medium to the second, then i is termed the CRITICAL ANGLE (*q.v.*). The ray in this case passes along the surface of separation of the media. If the angle of incidence exceed i, the ray is entirely reflected at the surface of separation, the angles in this case following the laws of reflection. This phenomenon is termed TOTAL INTERNAL REFLECTION.

Total Reflection. *See* TOTAL INTERNAL REFLECTION *and* CRITICAL ANGLE.

Touch (*Plumb.*) Tallow used in plumbing.

Touch Box (*Plumb.*) A box used by plumbers to keep tallow in.

Touch Hole (*Eng.*) A name sometimes applied to the opening in the cylinder of a gas engine through which ignition is effected. *See* GAS ENGINES.

Tough Pitch. *See* COPPER *and* POLING.

Tourbillon (*Watches*). A rotary carriage containing the escapement. It turns continuously round inside the watch in some short interval of time, so that the watch records the *mean rate* of the different vertical positions, thus practically removing a troublesome source of error. *Cf.* KARRUSEL.

Tourmaline (*Min.*) A silicate of boron, aluminium, and (magnesium, iron, lithium, potash); composition very complex. Rhombohedral, with the prisms generally triangular. Colour very variable, from black (Schorl), dark blue, green, pink, to colourless. The varieties rubellite, indicolite, Brazilian sapphire, Brazilian emerald, and peridot of Ceylon are mentioned under PRECIOUS STONES. Finer varieties are used in jewellery, and are found in Ceylon, Siberia, Brazil, and Ava. Common varieties are very widely distributed.

Tourmaline Forceps (*Phys.*) A device for holding a crystal, etc., between two plates of Tourmaline (*q.v.*) which serve as a polariser and analyser respectively in simple observations on polarisation. *See* POLARISATION.

Tourney Helm (*Arm.*) A form of helmet worn in the tourneys of the fifteenth and sixteenth centuries. The face opening was large and was protected by light iron bars fixed transversely and having spaces between. *Cf.* TILTING HELMET.

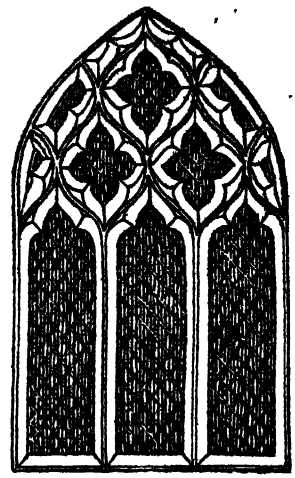
Tow (*Linen Manufac.*) In the process of dressing flax it is combed or hackled. This draws out all the short, twisted, and broken fibres, which are called Tow and are carded and spun for coarse yarns and ropes. *See* LINEN MANUFACTURE.

Town Refuse. *See* WASTE PRODUCTS *and* SANITATION.

T-piece (*Eng., etc.*) An object (*e.g.* a branching pipe) of the form of the letter T.

Trabeated (*Architect.*) (1) A style of architecture in which columns and lintels are the principal structural features. (2) Furnished with an entablature.

Tracery (*Architect.*) The ornamental pierced stonework in the head of a Gothic window. The same name is also given to similar work executed in stone or wood in canopies, etc. *See* BAR TRACERY, PLATE TRACERY, *and* FLAMBOYANT TRACERY.



TRACERY.

Trachyte (*Geol.*) Eruptive rocks of sub-acid composition (60 to 65 per cent. of silica) which have consolidated under smaller pressure than the corresponding plutonic rock of similar chemical composition (syenite), and therefore are not entirely crystalline throughout. The chief minerals occurring in Trachytes are Orthoclase, and certain other Felspars (*q.v.*), Hornblende, and sometimes Augite, Mica, Magnetite, etc. Quartz sometimes occurs; the rock is then termed a QUARTZ TRACHYTE.

Tracing. A copy of a drawing made on transparent paper or tracing cloth (*q.v.*), which is laid over the original, the lines being then drawn exactly over those of the original drawing.

Tracing Cloth. Smooth transparent linen on which a tracing (*q.v.*) is made. It is sized on one side.

Tracing Machine (*Joinery, etc.*) A machine for cutting or carving ornamentation on woodwork. A cutter is carried on the end of a swinging arm which is guided by some form of template; this cutter roughs out the carving very rapidly and with very little attention.

Tracing Paper. Ordinary unsized paper coated on one side with a varnish of Canada balsam and turps, or treated with wax; used for making a tracing (*q.v.*).

Track Circuit Signalling (*Civil Eng.*) *See* RAILWAYS.

Tracker (*Music*). A thin flat or round strip of wood used in the mechanism of the organ, for pulling the pull-down wire or for conveying leverage from one part to another. *See* ORGAN, *p.* 439. The tracker differs from the sticker in having to pull whilst the sticker always pushes. For this reason each end of the tracker is provided with a screw which when being passed through the backfall or roller arm or other lever is held in position by a leather button.

Traction (*Eng.*) The drawing or pulling of vehicles along a road or track. *See also* ELECTRIC TRACTION *and* RAILWAYS.

Traction Engine (*Eng.*) A form of locomotive adapted for use on common roads. The most usual form has a boiler of the locomotive type (*see* BOILERS) on top of which is mounted a horizontal engine with one or two cylinders. The engine is carried on four wheels, the two front ones being small and mounted on a bogie under the smoke box, so that by turning the bogie by means of suitable gear the engine can be steered. The hind wheels are large, and the motion of the engine is transmitted to one of them by means of toothed wheels. These wheels can be thrown out of gear, so that the engine can be used as a stationary engine when required, the power being taken from the crank shaft of the engine, which is provided with a driving pulley. A heavy flywheel and a governor are also fitted, completing the equipment necessary for a stationary engine, as distinguished from a locomotive.

Tractive Force (*Eng.*) The force necessary to draw a vehicle on a level surface, *i.e.* to overcome frictional resistance.

Trade Wastes. *See* WASTE PRODUCTS.

Trade Winds (*Meteorol.*) Prevailing winds occurring in tropical regions, due to the rush of cold air from cooler zones lying to the north and south. If the earth were at rest, these winds would blow nearly due N. and S., but in consequence of the earth's rotation they are displaced and appear to come from the N.E. and S.E.

Tragacanth, Gum Dragon, *or* **Gum Tragacanth** (*Botany*). A natural exudation of gum from the bark of the stem of several spiny shrubs of the genus *Astragalus* (*Leguminosæ*). Native to Asia Minor and the surrounding districts. Used in pharmacy, in the textile trades, and as a mucilage in marbling the end papers and edges of books. *See* GUMS.

Trailing Axle, Springs, Wheels, etc. (*Eng.*) The hinder axle, wheels, etc., of a locomotive, *i.e.* the wheel, etc., situate behind the driving wheels.

Trailing of a Dyke (*Geol.*) *See* HEAVES.

Trails (*Astron.*) If a camera be pointed to the sky on a dark and clear night, the images of the stars on the photographic plate will not be points but arcs, called STAR TRAILS. Shooting stars also leave trails in the sky for a few seconds.

Train (*Clocks and Watches*). A system of toothed wheels and pinions. In ordinary clocks and watches the slowest, or first wheel of the train counting from the motive power, is called the MAIN or GREAT WHEEL; the second wheel of the going train usually carries the minute hand and is called the CENTRE WHEEL. (In those required to go longer than the usual periods, one or more wheels and pinions are interposed between the great wheel and centre pinion; these are called INTERMEDIATE WHEELS and PINIONS.) The centre wheel drives the third pinion to which the third wheel is fixed; this latter drives the fourth pinion which carries the seconds hand and turns once per minute. In clocks, the fourth pinion generally carries the escape wheel, but in watches, with their more rapid vibrations, the fourth wheel drives the escape pinion to which the escape wheel is fixed.

—— (*Eng.*) A set of moving parts connected together; *e.g.* a set of toothed wheels gearing together.

Train of a Comet (*Astron.*) *See* TAIL OF A COMET.

Train Oil. A term commonly applied to the oil obtained from the blubber of the Right Whale (*Balæna*), and from certain other species. It is used for lubrication, but is greatly inferior to sperm oil.

Tram (*Mining*). A box-like four wheeled vehicle running on tram lines; used for transporting coal below the surface of a coal mine, or for conveying it from the pit mouth to the place of shipment. *Also termed* CORF, SKIP, *and* TUB.

—— (*Silk Manufac.*) Silk doubled and lightly spun, used for weft purposes. *Cf.* ORGANZINE

—— *or* **Tram Car** (*Civil Eng.*) A vehicle provided with flanged wheels running on a tramway (*q.v.*) It is drawn by horses, a cable running in a slotted conduit, or by electric power. *See* ELECTRIC TRACTION.

Trammels (*Eng., etc.*) The holders for the pencil and compass points used in beam compasses (*q.v.*) They can slide along a wooden bar, and can be fixed in any suitable position by means of set screws.

Tramway (*Civil Eng.*) A track formed by rails laid flush with the surface of the road along which they run, in order to permit the use of the road by ordinary traffic, as well as by vehicles running on the rails. The sleepers, if used, are entirely below the surface, and are commonly longitudinal; but the rails may be laid direct on a concrete foundation, the wide flat base providing sufficient support.

Tranquillo (*Music*). Quietly, calmly.

Transepts (*Architect.*) The parts of a cruciform church forming on plan the arms of the cross.

Transfer Printing (*Pot.*) Printing by transfer may be either from copper plate or from lithographic stone. The design is first either engraved upon the copper plate or drawn upon the stone; it is then printed upon thin paper. The paper is laid print downwards upon the ware, to which the print adheres and the paper is washed off, leaving the print "transferred" to the ware.

Transformation of Energy. The energy of a body or system, that is, its capacity for doing work, may exist in a variety of forms—*e.g.* Mechanical Energy, Chemical Energy, Thermal Energy, Electrical Energy. In general, energy can be changed from one of these forms to another—for example, the burning of coal or gas produces heat (thermal energy), which may be converted by an engine into mechanical energy, and the mechanical energy may be converted by a dynamo into electrical energy. The electrical energy may in turn be converted into mechanical energy, as when the current is employed to drive a motor; or it may be converted into heat (thermal energy) if the current be used for heating or lighting; or it may be converted into chemical energy by using the current to electrolyse some chemical compound.

The following table indicates some of the methods by which the changes from one form of energy to another may be effected. Each process or method quoted is the one by which the form of energy corresponding to the *line* in which it occurs may be converted into the form given at the head of the *column*. Certain cases of transmission of energy are added for the sake of comparison; these are indicated in the table

in italics, as they are not in the proper sense instances of the transformation of energy. It will be observed that no instances of the transformation of chemical energy into mechanical energy, and *vice versâ*, are given, as no cases of *direct* transformation are known. Chemical energy is obviously capable, however, of transformation into heat energy, and thus in turn into electrical or mechanical energy.

	Mechanical energy.	Thermal energy.	Electrical energy.	Chemical energy.
Mechanical energy	*Machines in general (transmission of energy).*	Friction, compression, percussion.	Electrical machines (friction and influence), dynamos.	?
Thermal energy .	Steam and gas engines: explosions, etc.	*Conduction (transmission of energy).*	Thermo-electric couples.	Production of endothermic compounds.
Electrical energy .	The mechanical effects produced by magnets, electric currents, electrical discharge, etc.	Heating effects of the electric current or discharge.	*Transformers (transmission of energy).*	Electrolysis: the process of charging accumulators.
Chemical energy .	?	Production of heat by chemical action.	Primary cells: discharge of accumulators.	Chemical actions in general.

Transformers (*Elect.*) A transformer is a device by which a small current at a high voltage or "pressure" is converted into a larger current at a lower voltage. In the majority of cases both these currents are alternating currents of the same frequency, and the apparatus then used is the ordinary ALTERNATE CURRENT TRANSFORMER. This consists in its simplest and most typical form of a CORE built up of thin plates of soft iron so as to produce a continuous magnetic circuit, and is usually in the shape of a rectangular frame. On this core are wound the PRIMARY and SECONDARY COILS, the number of turns of wire in the two coils being approximately proportional to the voltages of the primary and secondary currents. Thus, if a primary current at 2,000 volts is to be transformed into a current at 100 volts, the ratio of the turns in the two coils will be about 20 to 1. The action of the transformer depends upon the periodic change in the magnetic flux in the core which is induced by the variations of the primary current. As the same flux passes through the secondary coil, an E.M.F. is thereby set up in this coil, giving rise when the secondary circuit is completed to an alternating current of the same frequency as the primary current. The efficiency of a good transformer is very high, the total loss of energy being in some cases not more than 3 or 4 per cent. The chief sources of loss are: (1) Hysteresis (*q.v.*); (2) Eddy or Foucault Currents (*q.v.*); (3) Resistance of the windings. In each case the lost energy appears in the form of heat, which raises the temperature of the transformer, and is ultimately radiated from its surface. Cooling is sometimes aided by immersing the apparatus in oil. Another class of transformers are more often termed CONVERTERS or ROTARY CONVERTERS; they are used in the transformation of alternate currents to continuous currents (or *vice versâ*), or for changing the voltage of continuous currents. In the first case, an alternating current motor drives a continuous current dynamo (or *vice versâ*); in the second case, both dynamo and motor are of the continuous current type. In certain forms there is but one field magnet and one armature, the latter carrying two sets of windings.

Transit (*Astron.*) The crossing of the meridian by any celestial body. Also applied in a special sense to the passage of one celestial body in front of another, *e.g.* the passage of the planets Mercury or Venus in front of the sun.

Transit (*Surveying*). The term used in America for the Transit Theodolite (*q.v.*)

Transit Circle (*Astron.*) A telescope turning on a horizontal axis fixed due east and west, so that the instrument always points to the meridian. A large vertical graduated circle is fixed to the telescope so that the north polar distance, or altitude, or declination of the body under observation can be determined. *See* MERIDIAN CIRCLE.

Transition (*Architect.*) A period in architectural history during which a change from one style to another is progressing. The term is generally used to denote the transition from the Romanesque to the Gothic. *See* DECORATED.

—— (*Music*). A change of key. It is usually used to denote a *temporary* modulation.

Transition Elements (*Chem.*) A name given to the elements of Group VIII. of the PERIODIC SYSTEM (*q.v.*)

Transit Theodolite (*Surveying*). A theodolite in which the telescope is capable of complete rotation round its horizontal axis, movement in this plane being limited in other forms. *See* THEODOLITE.

Transmission Gratings (*Light*). *See* DIFFRACTION GRATINGS.

Transmission of Power. Power is transmitted or communicated from place to place in a great variety of ways; but in engineering phraseology the above term usually refers only to the transmission of actual motion. This is effected by shafts, belts, cables, etc. Power may also be transmitted by means of fluids under pressure (hydraulic transmission), by means of electric currents, etc. Steam engines may also be worked at a considerable distance from their boilers if the pipes are well coated with non-conductors, and compressed air motors are almost invariably placed a long way from the compressors which supply the air by which they are driven.

Transmitter (*Elect.*) The apparatus employed in sending a message either by the TELEGRAPH or TELEPHONE (*q.v.*)

Transom (*Build.*) The horizontal member of a frame between the head and sill, *e.g.* a horizontal timber crossing the frame of a door below the fanlight; the crossbar or horizontal member of a mullion window.

—— (*Eng.*) A transverse piece of timber serving as a strut between two parallel members, *e.g.* between longitudinal sleepers.

Transporter (*Eng.*) An appliance for moving material in bulk, or large numbers of separate objects, from place to place without the aid of manual labour; more often termed a CONVEYOR. The material may be carried on broad belts, or a series of buckets running on chains, the whole machine being driven by power.

Transpose (*Typog.*) In imposing, to place the pages in wrong order. This word, or more generally its abbreviated form *trs.*, written in the margin of a proof signifies that a word, line, or other portion of printed matter indicated is to be transferred to another position. *See p.* 568.

Transposing Instruments (*Music*). Are divided into those which transpose (1) an octave, such as the Double-bass, Contra-bassoon, and Piccolo; (2) some interval other than the octave (or at times the octave) such as the Clarionets, Basset Horn, Saxophones, some Oboes, Cor Anglais, some Flutes, some Piccolos, Horns, Trumpets. The exact transposition in each instance is given under the article MUSICAL INSTRUMENTS, *pp.* 426-38.

Transposition (*Music*). A change of pitch, or clef. In transposition every interval of a musical passage is reproduced either at another pitch, that is, (1) in another key as at Example 1, or (2) at the interval of an octave in the same key as at Example 2, or (3) in another key practically at the same pitch, as at Example 3; this last is known as enharmonic transposition (*see* ENHARMONIC), or (4) from one clef to another at the same pitch as at Example 4.

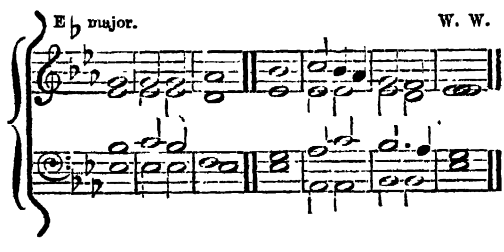
EXAMPLE 1.—TRANSPOSITION IN NEW KEY; AN AUGMENTED SECOND ABOVE.

EXAMPLE 2.—TRANSPOSITION AN OCTAVE BELOW, AND IN ANOTHER CLEF.

EXAMPLE 3.—ENHARMONIC TRANSPOSITION.

EXAMPLE 4.—FROM ONE CLEF TO ANOTHER AT THE SAME PITCH.

Transposition is also used to change a passage from a major to a minor mode, or *vice versa*, as in the following example:



See also TRANSPOSING INSTRUMENTS.

Transverse Section. A section (*q.v.*) across an object, *i.e.* at right angles to the longitudinal axis or direction of greatest length.

Trap (*Sanitation*). In its simplest form a trap is a bend in a pipe which retains water that is automatically replaced whenever the trap is used, thus preventing the return flow of noxious gases. The trap most commonly used is the Siphon Trap (*q.v.*) The essentials of a good trap are: (*a*) an efficient water seal, *e.g.* in the siphon trap the water should stand at least three-quarters of an inch above the openings of the bend; (*b*) the trap should be self-cleansing; (*c*) every portion should be effectually cleansed by each flush. Other more or less efficient traps are the Midfeather (*q.v.*); the bell trap, a modification of the foregoing; and the ball trap, or Cousler's trap, in which a ball rises with the rise of water in the sewer and closes the aperture. In the case of traps to water closets, a ventilating pipe is generally connected with the outer side of the trap to prevent siphoning. *See also* SANITATION.

—— (*Weaving*). The term applied to a breakage of warp threads in a loom through faulty working.

Trapezium. A plane figure having four unequal sides, no two of which are parallel.

Trapezoid. A plane four sided figure having two sides parallel.

Trappean Rocks (*Geol.*) Eruptive or igneous rocks, which have consolidated below the surface of the ground, though not at the greatest depths as in the case of Plutonic Rocks (*q.v.*) The name is derived from the Swedish word *Trappa* (a flight of steps), which was applied owing to the steplike form in which these rocks frequently occur.

Travel (*Eng.*) The distance through which a part of some mechanism can move in a straight line.

Traveller (*Cotton Spinning*). In Ring spinning, a small metal loop or ring which guides the yarn when being wound upon the spindle. *See* RING FRAME.

—— *or* **Travelling Crane** (*Eng.*) *See* CRANES.

Traverse (*Surveying*). A series of consecutive lines, the directions and lengths of which have been ascertained.

——, **Traverse Net** (*Lace Manufac.*) A term applied to John Heathcote's traverse Brussels net; it also applies to other nets and laces where certain threads are traversed or laid crosswise over a more limited area.

Traverse Tables (*Surveying*). Tables which show by inspection the co-ordinates of any point in a traverse.

Traversing (*Eng.*) The ordinary operation of turning in a self-acting lathe, in which the tool moves longitudinally, as opposed to Surfacing (*q.v.*), in which the tool travels across the bed. The term "traversing" is also applied to various longitudinal movements in machine tools and other mechanism.

Traversing Bridge (*Civil Eng.*) A bridge formed by a girder like structure, which can be drawn backward by hydraulic or other power, in order to furnish an opening through which vessels can pass. Examples occur in the Millwall Docks and also at Barry.

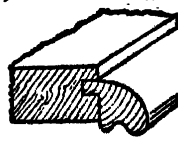
Traversing Mandrel (*Eng.*) A lathe mandrel (*q.v.*) which is capable of longitudinal motion. This motion is usually communicated to the mandrel by means of a short screw attached to the mandrel; the screw runs through a nut fixed to the headstock, and therefore the mandrel advances in each revolution through a distance equal to the pitch of the screw. If a piece of metal held in a chuck be acted upon by a tool which is kept fixed, a screw thread will be cut upon it, of pitch equal to that of the screw fixed to the mandrel. This device is very convenient for cutting small screws and for ornamental and fancy turning.

Traversing Screw (*Eng.*) A screw employed for producing a longitudinal motion; the leading screw of a lathe is a particular example.

Traverso (*Music*). Crossways. *See* FLUTE *under* MUSICAL INSTRUMENTS, *p.* 434.

Travertine (*Geol.*) Calcareous rock formed by the deposition of carbonate of lime, together with other materials, by underground water.

Treacle Moulding (*Joining*). A moulding of the form shown in the figure.


TREACLE MOULDING.

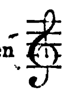
Tread (*Build.*) The part of a stair or step on which the foot rests.

—— (*Eng.*) The bearing surface of a wheel on road or rail. The parts of the surfaces of a rail and a wheel which come in contact with each other are termed the Tread of the Rail and the Tread of the Wheel respectively.

——, **Width of** (*Cycles*). The distance between the two inner flanges of the pedals, measured in a line parallel to the crank axle.

Treadle. The lever on which the foot is pressed, in order to communicate motion (not necessarily rotary) to a machine.

Treadle Machine (*Print.*) A small printing machine of the platen order, worked by the foot of the operator.

Treble (*Music*). (1) The name given to the clef which was originally written as the letter *g* or G, now written  on the second line of the stave. *See* STAVE *and* SCORE. (2) The name given to soprano voices, especially boys'.

Treble Geared Lathe (*Eng.*) A lathe having back gear (*q.v.*), in which three wheels and three pinions are used, so that the velocity of the mandrel is reduced to a still greater extent than by ordinary back gear.

Trebles (*Met.*) Sheet iron of gauge varying from Nos. 25 to 27 of the Birmingham Wire Gauge. *See* WIRE GAUGES.

Tre Corde (*Music*). Without the left pedal. *Cf.* UNA CORDA.

Tree Calf (*Bind.*) A brown calf binding which has been stained to imitate a conventional tree-like pattern.

Treflée (*Her.*) *See under* CROSS *and* TREFOIL.

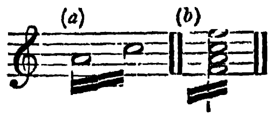
Trefoil (*Architect.*) A cusped opening in Gothic tracery formed with three foils or spaces between cusps. *See* FOIL, CINQUEFOIL, QUATREFOIL, MULTIFOIL, CUSP, *and* TRACERY.

—— (*Her.*) A leaf having three cusps like a clover leaf. Treflée indicates adorned with Trefoils.

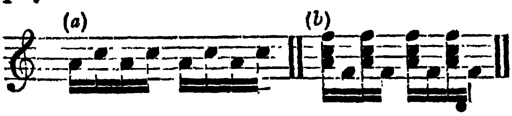
Tremolite (*Min.*) A calcium magnesium Amphibole (*q.v.*) $3MgO \cdot SiO_2 \cdot CaO \cdot SiO_2$. In long bladelike crystals of a greyish or white colour. Also in fibrous and columnar masses. From Switzerland and many places where there are metamorphic rocks.

Tremolo (*Music*). In a tremulous manner. Tremolo may be divided into reiterated notes played as rapidly as possible, and written thus:

and into divided chords played quickly and written thus:



played—



Tremulant *or* **Tremolo** (*Music*). Mechanism in the organ and harmonium, which acts on the supply of wind in such a manner as to disturb the steadiness of the supply, thus causing a throbbing sensation. Tremulants are of many patterns.

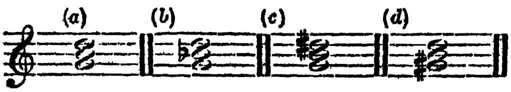
Trenail *or* **Treenail** (*Eng.*) Wooden spikes used to fix railway chairs to the sleepers; the timber from which they are made is dried and compressed, so that the subsequent swelling holds the trenails firmly in position.

T-Rest *or* **Tee-Rest** (*Eng., etc.*) The T-shaped support for a tool used in hand turning.

Trestle Bridges (*Civil Eng.*) Bridges usually at a high level, carried on timber or iron supports resembling ordinary trestles in form. They are of great use in accelerating railway construction, but are in many cases replaced by more permanent structures when the line is in full working order.

Trestles. A form of stool with a long narrow top, and four (rarely three) legs spreading out towards the base.

Triad (*Music*). A chord consisting of three notes a third above each other. A triad may be: major (*a*), minor (*b*), augmented (*c*), diminished (*d*). The first two are perfect, having the extreme notes a perfect fifth apart, the last two, not having a perfect fifth, are called imperfect.



Triad Elements (*Chem.*) Same as trivalent element. *See* VALENCY.

Trial Level (*Civil Eng.*) A preliminary measurement of the general elevation of ground along which a railway, canal, etc., is to be constructed.

Triangle (Triangolo) (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 445.

Triangle of Forces. If three forces lying in a plane be in equilibrium, they may be represented in magnitude and direction by the sides of a triangle. *Cf.* POLYGON OF FORCES *under* GRAPHIC STATICS.

Triangular Rule *or* **Scale.** A rule or scale consisting of a bar of wood whose cross section is a triangle, with suitable graduations on each face.

Triangulation (*Astron.*) The application of trigonometry to the determination of distances.

—— (*Surveying*). The method of making a survey by taking the angles to other stations from the ends of the base line, and then from these stations to further ones, thus covering the area with a network of imaginary triangles all the angles of which have been measured. From the known length of the base line, the sides of the triangles can then be calculated.

Trias (*Geol.*) The system at the base of the Secondary Rocks (*see* STRATA, TABLE OF, *in Appendix*). The name is derived from the triple division of the system, as it occurs in its most typical form, in Germany; in England one of these divisions is absent, the two existing divisions being the UPPER TRIAS or KEUPER and the LOWER TRIAS or BUNTER.

Triatomic Molecule (*Chem.*) An elementary molecule containing three atoms of the element. The only known example is Ozone (*q.v.*)

Triblet (*Eng.*) (1) A round rod or mandrel, which is put through the hole in a nut, etc., while it is being finished by a blacksmith. (2) A mandrel on which tubing is drawn.

Triboluminescence (*Phys.*) The production of luminescence by friction, as when a lump of sugar is crushed in the dark. This property is possessed by many crystals, *e.g.* Diamond, Quartz, and Uranium Nitrate.

Tributyrin (*Chem.*) $\begin{array}{l} CH_2OOC \cdot C_3H_7 \\ | \\ CHOOC \cdot C_3H_7 \\ | \\ CH_2OOC \cdot C_3H_7 \end{array}$ (Glyceryl tributyrate).

An oil; boils at 285°. Said to occur in butter, but it is probable that one or two of the butyric acid residues are replaced by higher fatty acid residues in butter fat, so that tributyrin itself is not present. It can be obtained by prolonged boiling of glycerine and butyric acid.

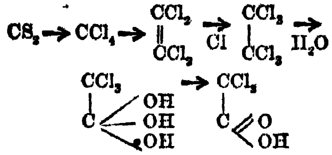
Trichloracetaldehyde (*Chem.*) A synonym for CHLORAL (*q.v.*)

Trichloracetic Acid (*Chem.*) $\begin{array}{l} CCl_3 \\ | \\ COOH \end{array}$ A white crystalline solid; melts at 52°; boils at 195°; deliquescent and very soluble in water. It has a pungent smell; it is an antiseptic and caustic, blistering the skin. Trichloracetic acid is a powerful acid, comparable in strength with the strongest mineral acids. Potassium amalgam converts its aqueous solution into acetic acid. Alkalis convert it into chloroform.

$$\begin{array}{l} CCl_3 \\ | \\ COONa \end{array} + HONa = CCl_3H + CO(ONa)_2$$

It is synthesised as follows: Carbon disulphide is

converted into carbon tetrachloride by the action of sulphur chloride in presence of iron; the carbon tetrachloride, when passed through a red hot tube, gives tetrachlorethylene; the latter exposed to sunlight in presence of chlorine and water gives trichloracetic acid:



It can be obtained by direct chlorination of acetic acid, or by oxidising chloral hydrate with fuming nitric acid.

Trichord (*Music*). Three strings. A modern pianoforte is called a trichord pianoforte because the majority of the notes have three strings each, tuned in unison. *See* PIANOFORTE, *p.* 430.

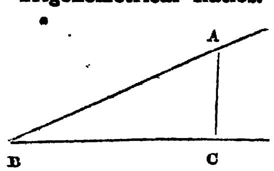
Tridymite (*Min.*) An oxide of silicon, SiO_2, occurring in small hexagonal plates in trachyte in Antrim and on the Rhine. *Cf.* QUARTZ.

Triforium (*Architect.*) *See* CLERESTORY.

Triglyphs (*Architect.*) The structural part of the frieze in a Doric entablature. There are two vertical grooves on the face of each triglyph, and a chamfer or half groove on each edge. *See* ENTABLATURE; METOPE; ARCHITECTURE, ORDERS OF; DORIC; DIGLYPH; DITRIGLYPH; *and* MEROS.

Trigonometer (*Surveying*). An instrument used in plotting a survey and by means of which the coordinates of a point, whose distance and bearing have been determined, may be read off.

Trigonometrical Ratios. Let θ be any angle; then if a line AC be drawn perpendicular to BC, the following terms are applied to the ratios between the sides of the right-angled triangle thus formed.



1. $\dfrac{\text{Perpendicular}}{\text{Hypothenuse}} = \dfrac{AC}{BA}$ termed the SINE of angle θ.
2. $\dfrac{\text{Base}}{\text{Hypothenuse}} = \dfrac{BC}{BA}$ „ „ COSINE „ „
3. $\dfrac{\text{Perpendicular}}{\text{Base}} = \dfrac{AC}{BC}$ „ „ TANGENT „ „
4. $\dfrac{\text{Hypothenuse}}{\text{Perpendicular}} = \dfrac{BA}{AC}$ „ „ COSECANT „ „
5. $\dfrac{\text{Hypothenuse}}{\text{Base}} = \dfrac{BA}{BC}$ „ „ SECANT „ „
6. $\dfrac{\text{Base}}{\text{Perpendicular}} = \dfrac{BC}{CA}$ „ „ COTANGENT „

In mathematics these ratios are abbreviated to *sin θ, cos θ, tan θ, cosec θ, sec θ, cot θ* respectively. The difference between unity and the cosine of an angle is termed the VERSED SINE (abbreviated *versin θ*), *i.e. versin* $\theta = 1 - \cos\theta$. Tables of these ratios are published, giving their values up to seven places of decimals. Their properties are dealt with in works on trigonometry.

Trigonometry. The branch of mathematics dealing with the properties of triangles and the measurement of angles.

Trihedral Angle. The figure formed by three planes which meet at a point.

Trihydric Alcohols and Phenols (*Chem.*) Alcohols and phenols containing three hydroxyl groups. For an example of a trihydric alcohol *see* GLYCERINE; for a phenol *see* PYROGALLOL *and* PHLOROGLUCIN.

Trill (*Music*). *See* ORNAMENTS (*Music*).

Trilobites (*Geol.*) An important group of fossils occurring in the Lower Palæozoic Rocks; so called from the division of the fossil into three distinct areas by two longitudinal furrows. The exact zoological position of the Trilobites is difficult to determine, but they belong to the *Arthropoda*, the Sub-Kingdom which includes the *Crustacea* (Crabs, Lobsters), *Arachnida* (Spiders), etc. Some of the chief Trilobites and the geological systems to which they belong are as follows:

CAMBRIAN SYSTEM.

Paradoxides.	*Microdiscus.*
Olenus.	*Psilocephalus.*
Agnostus.	

ORDOVICIAN SYSTEM.

Asaphus.	*Æglina.*
Ogygia.	*Calymene.*
Phacops.	*Trinucleus.*
Ampyx.	

SILURIAN SYSTEM.

Phacops.	*Chierurus.*
Homalonotus.	*Harpes.*
Calymene.	

A few Trilobites also occur in the DEVONIAN and CARBONIFEROUS SYSTEMS.

Trimethylamine (*Chem.*) $N(CH_3)_3$. A gas; boils at 3·5°; smells strongly of fish; very soluble in water; readily inflammable. It is a strong tertiary base uniting with acids to form salts, and with alkyl iodides to form quaternary ammonium compounds (*q.v.*) Examples:

$N(CH_3)_3HCl$.	$\{N(CH_3)_3 . H\}_2PtCl_6$	$N(CH_3)_4I$
Trimethylamine hydrochloride.	Platinum chloride double salt.	Tetramethyl ammonium iodide.

Trimethylamine unites directly with carbon disulphide, forming $CS_2 . N(CH_3)_3$ with evolution of heat. Trimethylamine occurs in herring brine, in some blossoms such as hawthorn and pear, in a number of plants, *e.g.* stinking goosefoot, in putrifying flesh of the most various kinds, in Gorgonzola cheese, and sometimes in urine. It can be obtained in quantity from the "vinasse" of the beetroot sugar industry. In this industry the molasses are fermented for alcohol which is distilled off; the residual liquid ("vinasse") is evaporated to dryness, and the dry residue distilled. The distillate is neutralised with sulphuric acid, and again distilled; the residual liquid consists largely of the sulphates of ammonia and trimethylamine, which can be partially separated by crystallisation, the former sulphate being the less soluble. The mother liquor is distilled with quicklime, and the distillate received in hydrochloric acid. The two hydrochlorides can be partially separated by crystallisation, ammonium chloride being the less soluble. The mother liquor is boiled down till its boiling point reaches 200°—the residue is trimethylamine hydrochloride. When methyl iodide is heated

with alcoholic ammonia in closed vessels, tetramethyl ammonium iodide, and the hydriodides of ammonia, methylamine, dimethylamine, and trimethylamine, are obtained. From the first of these five compounds trimethylamine can be obtained by converting it into the hydroxide by the action of moist silver oxide and distilling the hydroxide. The tetramethyl ammonium iodide is easily separated from the mixture by distilling with caustic potash, when it remains behind unchanged. The four bases all distil over, and are condensed in a receiver cooled by a freezing mixture, a part of the ammonia and methylamine escaping. To the liquid mixture ethyl oxalate is added:

Methylamine forms $\begin{array}{l} CONHCH_3 \\ | \\ CONHCH_3 \end{array}$ Dimethyl oxamide.

Dimethylamine forms $\begin{array}{l} CON(CH_3)_2 \\ | \\ COOC_2H_5 \end{array}$ Ethyl dimethyl oxamate.

} Separated by the action of cold water, which dissolves the ethyl dimethyl oxamate. On hydrolysis they yield the amines.

Trimethylamine is unacted on, and may be distilled off. *See also under* Betaine, Choline, Narcotine, *and* Neurine.

Trimethylene (*Chem.*) (1) The compound trimethylene $H_2C \overset{CH_2}{\triangle} CH_2$ is a gas; burns with a bright flame. With bromine it yields trimethylene bromide, and with hydriodic acid normal propyl iodide. It is obtained from trimethylene bromide by boiling with sodium. It would be better called cyclopropane. From it are derived a series of homologues and carboxylic acids. The carboxylic acids can be obtained in several ways, *e.g.* (i) by the action of ethylene dibromide on ethyl disodiummalonate:

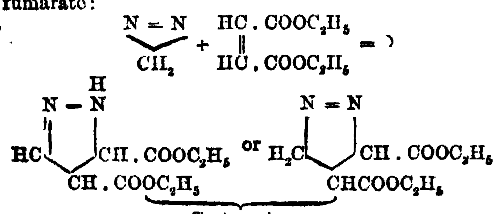
$$\begin{array}{l} CH_2Br \\ | \\ CH_2Br \end{array} + Na_2C\begin{array}{l} \diagup COOC_2H_5 \\ \diagdown COOC_2H_5 \end{array} =$$

$$\begin{array}{l} H_2C \\ | \\ H_2C \end{array} \rangle C\begin{array}{l} \diagup COOC_2H_5 \\ \diagdown COOC_2H_5 \end{array} + 2NaBr$$

On hydrolysing, and heating the resulting acid, trimethylene monocarboxylic acid is obtained:

$$\begin{array}{l} H_2C \\ | \\ H_2C \end{array} \rangle C\begin{array}{l} \diagup COOH \\ \diagdown COOH \end{array} = \begin{array}{l} H_2C \\ | \\ H_2C \end{array} \rangle CH . COOH$$

(ii) By the action of diazomethane (*q.v.*) on ethyl fumarate:



Tautomeric.
Diethyl — 4 : 5 pyrazolinedicarboxylate.

$$= H_2C \begin{array}{l} \diagup CH . COOC_2H_5 \\ | \\ \diagdown CH . COOC_2H_5 \end{array} + N_2$$

Cf. under Pyrazole. The 1 : 2 trimethylene dicarboxylic acids are known in the cis-and trans-forms. *See* Stereoisomerism. (2) The group—$CH_2 . CH_2 . CH_2$— is called trimethylene; it only occurs in combination, as for example in trimethylene bromide—

$$CH_2Br . CH_2 . CH_2Br,$$

and in glutaric acid (*q.v.*) Trimethylene Bromide is a colourless liquid; boils at 165°. With sodium it yields trimethylene (*q.v.*); with potassium cyanide it yields the nitrile of glutaric acid (trimethylene cyanide). It is prepared from allyl bromide (from allyl alcohol, amorphous phosphorus, and bromine) by the saturating it at about − 20° with hydrogen bromide and allowing the liquid to stand in sealed tubes at 30° for twenty-four hours, and repeating the process as long as allyl bromide can take up the gas:

$$\begin{array}{l} CH_2 \\ \| \\ CH \\ | \\ CH_2Br \end{array} + HBr = \begin{array}{l} CH_2Br \\ | \\ CH_2 \\ | \\ CH_2Br \end{array}$$

Trimmer (*Carp. and Join.*) A short joist running across an opening, and serving to support the ends of a number of other joists which have been shortened in order to form the opening. *See* Floors.

Trimmer Arch (*Build.*) The arch supporting the front hearth of an upper floor.

Trimmer Joists (*Carp. and Join.*) The joists supporting the ends of a trimmer (*q.v.*). Sometimes termed Trimming Joists.

Trimming (*Bind.*) Taking a shaving off the rough edge of the leaves of a book that is not to be cut down.

—— (*Carp. and Join.*) Supporting the cut ends of joists by means of a Trimmer (*q.v.*)

Trindle (*Bind.*) A thin flat implement of wood or metal in the shape of an elongated U; used in pairs for making the back of a book in boards assume a flat position previous to placing in the press for the operation of cutting the foredge. *See* Bookbinding.

Trinitrophenol (*Chem.*) *See* Picric Acid.

Trio (*Music*). (1) A musical composition for three voices or instruments. (2) The term given to the secondary movement of a march, minuet, etc. *See also* Repeat.

Triolein (*Chem.*) $\begin{array}{l} CH_2OOC_{17}H_{33} \\ | \\ CH.OOC_{17}H_{33} \\ | \\ CH_2.OOC_{17}H_{33} \end{array}$ (Glyceryl trioleate).

An oil; melts at − 6°; is oxidised on exposure to air, becoming acid; nitrous acid changes it to an isomer elaidin. For occurrence *see* Oleic Acid. It can be prepared from olive oil by allowing the oil to stand with occasional shaking over caustic soda solution for twenty-four hours; the soaps formed by hydrolysis of the other glycerides are dissolved in dilute alcohol when triolein remains. *See also* Iodine Absorption.

Trional (*Chem.*) $\begin{array}{l} CH_3 \\ C_2H_5 \end{array} \rangle C(SO_2C_2H_5)_2$ (Diethylsulphone methylethylmethane). White crystalline powder; melts at 76°; sparingly soluble in water, readily soluble in alcohol and ether. It is used as a hypnotic. Prepared from methylethyl ketone just as sulphonal (*q.v.*) is prepared from dimethyl ketone (acetone).

Trioses (*Chem.*) Sugars containing three carbon atoms. There are two of them:

Aldo-triose. Glycerine aldehyde. Glycerose.	Keto-triose. Glycerine ketone. Dioxyacetone.
CH_2OH	CH_2OH
$CHOH$	CO
CHO	CH_2OH

The aldose should exist in dextro-, lævo-, and inactive forms, but only the inactive form is known. A mixture of the two trioses is obtained by the oxidation of glycerine by means of bromine in presence of a weak alkali, such as lead hydroxide or sodium carbonate. The aldose can be obtained by boiling acrolein dibromide with much water and removing the hydrobromic acid by silver oxide: it is a crystalline solid which melts at 138°; reduces Fehling's solution; condenses on standing with a dilute alkali to β-acrose; yields an osazone (*q.v.*) The ketone can be obtained by the fermentation of a 5 or 6 per cent. solution of glycerine in broth by the sorbose bacterium (B xylinum) in 30 per cent. yield; also synthetically from symmetrical dibromacetone by the action of alkalis: it is a crystalline solid; no constant melting point; reduces Fehling's solution; alkali acts as on the aldose; yields an osazone.

Tripalmitin (*Chem.*) $\begin{array}{l} CH_2 . OOC . C_{15}H_{31} \\ | \\ CH \;. OOC . C_{15}H_{31} \\ | \\ CH_2 . OOC . C_{15}H_{31} \end{array}$ (Glyceryl tripalmitate).

A crystalline solid; melts at 50°, then solidifies, and melts again at 66°; nearly insoluble in alcohol; very soluble in ether; it occurs in many fats and especially in palm oil; it can be made from glycerine and palmitic acid. *See* Palmitic Acid.

Trip Gear (*Eng.*) The arrangement of levers and catches used for opening and closing the valves of Corliss engines, etc.

Triphenylcarbinol (*Chem.*) $HO-C{\left\langle\begin{array}{l} C_6H_5 \\ C_6H_5 \\ C_6H_5 \end{array}\right.}$

Crystallises in plates; melts at 159°; boils above 360°; soluble in benzene, alcohol, and glacial acetic acid. The solution in the latter solvent is turned yellow by addition of hydrochloric acid; the substance also dissolves in concentrated sulphuric acid with the same strong yellow colour—the colour is probably due to the same cause as that of a solution of triphenylmethyl in ionising solvents. *See* Triphenylmethyl. Its paratriamido derivative is the colour base of Pararosaniline (*q.v.*) When dissolved in acetyl chloride, it gives a violet colour, which passes into dark red, and finally yields triphenylchlormethane, but no acetate:

$(C_6H_5)_3C . OH + CH_3COCl = (C_6H_5)_3C . Cl + CH_3COOH.$

Triphenylcarbinol can be obtained in several ways: (1) from pararosaniline (*q.v.*); (2) from triphenylmethane (*q.v.*); (3) from benzophenone and magnesium phenylbromide. *See* Magnesium Compounds.

$$C{\left\langle\begin{array}{l} C_6H_5 \\ O \\ C_6H_5 \end{array}\right.} + Mg{\left\langle\begin{array}{l} C_6H_5 \\ Br \end{array}\right.} = C{\left\langle\begin{array}{l} C_6H_5 \\ C_6H_5 \\ OMgBr \\ C_6H_5 \end{array}\right.}$$

$$C{\left\langle\begin{array}{l} C_6H_5 \\ C_6H_5 \\ OMgBr \\ C_6H_5 \end{array}\right.} + H_2O = C{\left\langle\begin{array}{l} C_6H_5 \\ C_6H_5 \\ OH \\ C_6H_5 \end{array}\right.} + Mg{\left\langle\begin{array}{l} OH \\ Br \end{array}\right.}$$

(4) From triphenylchlormethane by solution in strong sulphuric acid and cautious addition of water. Yield 99 per cent.

$$Ph_3C . Cl + H_2SO_4 = HCl + Ph_3C . OSO_3H$$
$$Ph_3CO . SO_3H + H_2O = Ph_3C . OH + H_2SO_4$$

$(Ph = C_6H_5)$

Triphenylchlormethane (*Chem.*) $Cl-C{\left\langle\begin{array}{l} C_6H_5 \\ C_6H_5 \\ C_6H_5 \end{array}\right.}$

A white crystalline solid; melts at 108°—112°; soluble in benzene, carbon disulphide, and chloroform, sparingly soluble in ether. When heated over 250° it gives diphenylenephenylmethane $\left.\begin{array}{l} C_6H_4 \\ | \\ C_6H_4 \end{array}\right\rangle CH . C_6H_5$

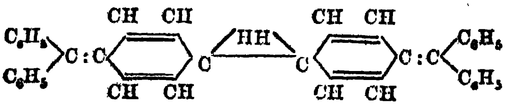
Its benzene solution, when allowed to stand in contact with certain metals such as zinc, silver, mercury, gives triphenylmethyl (*q.v.*) For the action of strong sulphuric acid *see* Triphenylcarbinol. *See also* Triphenylmethane. When heated with silver acetate it yields an acetate which melts at 37°. It is best prepared by condensing carbon tetrachloride with benzene by means of aluminium chloride. The two former, pure and dry, are placed in a flask with reflux condenser, and the aluminium chloride (from chlorine and aluminium) is added in portions of 10 grams at a time (CCl_4 1 part : C_6H_6 3·5 parts : $AlCl_3$ 1·25 parts). Then the mixture is heated for an hour on a water bath. The cooled product is poured in a thin stream on much powdered ice, and benzene is added from time to time, with constant stirring to keep the triphenylchlormethane in solution. The benzene is separated and washed with diluted hydrochloric acid, then water—the washings must be done quickly. The solution is dried over calcium chloride, then concentrated as far as possible on a water bath—over half separates in pure crystals, which may be filtered off and washed with dry ether. More can be obtained by working up the mother liquor.

Triphenylmethane (*Chem.*) $H-C{\left\langle\begin{array}{l} C_6H_5 \\ C_6H_5 \\ C_6H_5 \end{array}\right.}$

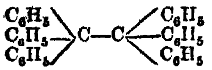
Colourless prisms or leaves; melts at 93°; boils above 300°; very soluble in benzene, ether, chloroform, less soluble in alcohol. On oxidation with chromic acid it gives triphenylcarbinol (*q.v.*) For its conversion into pararosaniline *see* Pararosaniline. Its paratriamido derivative is the leuco compound of pararosaniline. Triphenylmethane is best prepared from triphenylchlormethane (*q.v.*)—15 grams of this in powder are added to 60 cc. glacial acetic acid (in which it is little soluble); 15 grams of zinc powder are added, and carbon dioxide is passed through the liquid, which is kept efficiently stirred by a turbine for several hours at the ordinary temperature. The mixture is then gently warmed, filtered, and the zinc washed with warm glacial acetic acid. Water is added little by little to the filtrate, when the triphenylmethane crystallises out in good but slightly yellow crystals. It is washed with water, and recrystallised from benzene and alcohol. From benzene it crystallises with benzene of crystallisation. Yield of not recrystallised product 92 per cent.

Triphenylmethyl (*Chem.*) $C_{38}H_{30}$. The following formulæ have been successively suggested for this compound, which was discovered by Gomberg:

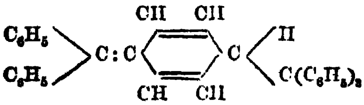
$\left.\begin{array}{l} C_6H_5 \\ C_6H_5 \\ C_6H_5 \end{array}\right\rangle C$ Gomberg's formula (trivalent carbon atom).



Heintschel's formula
(suggested to avoid a trivalent carbon atom).



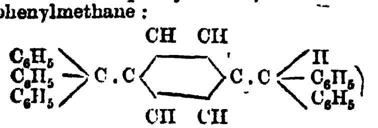
Tschitschibabin's formula
(hexaphenylethane).



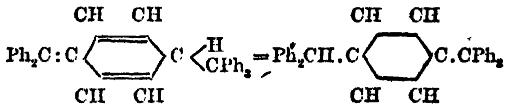
Jacobson's formula.

1-diphenylmethylene-4-triphenylmethyl-cyclohexadien (2, 5).

It is necessary to point out here that the compound called hexaphenylethane by Gomberg is a compound so called by Ullmann and Borsum, its discoverers; but Tschitschibabin has shown that in all probability it is not hexaphenylethane, but benzhydryltetraphenylmethane :



because it reacts quantitatively with only one molecular proportion of bromine, when exposed to sunlight and in carbon disulphide solution, forming a monobromide which readily hydrolyses to a carbinol. For this reason Tschitschibabin suggested the hexaphenylethane formula for Gomberg's triphenylmethyl, and the formula last written for benzhydryl-tetraphenylmethane. This compound will be referred to in what follows as hexaphenylethane U.B. Triphenylmethyl is a colourless crystalline solid, but turns yellow on keeping; it melts (out of air) at 145° to 147°, first blackening and turning red after melting; it distils at 208° under a pressure of 19 mm. mercury, but with decomposition, much triphenylmethane being formed. Its molecular weight was determined by the lowering of the freezing point of each of the following solvents—benzene, naphthalene, nitrobenzene, dimethylaniline, parabromtoluene, phenol—in an atmosphere of carefully purified atmospheric nitrogen; the mean of twelve experiments was 477, while $(C_6H_5)_3C$ requires 243. Gomberg inclines to the view that the result is due to molecular association. Its electric conductivity in liquid sulphur dioxide is comparable to that of many salts; thus its molecular conductivity increases from 8·24 at a dilution of 24 litres to 39·6 at a dilution of 2138 litres. It is very soluble in chloroform and carbon disulphide; pretty soluble in carbon tetrachloride and toluene. From toluene it crystallises beautifully, but the crystals contain toluene. It is also soluble in ethyl acetate and ether; the crystals formed from these solvents are compounds $(C_6H_5)_3C \cdot CH_3COOC_2H_5$ and $\{(C_6H_5)_3C\}_2(C_2H_5)O$. Non-ionising solvents yield colourless solutions; ionising solvents yield yellow solutions (halochromic, *i.e.* the production of colour without the presence of any colour producing radical or grouping). This yellow colour is ascribed by Gomberg to the presence of the ion $(C_6H_5)_3C$—. In its reactions triphenylmethyl behaves as a strongly unsaturated compound; thus it unites, as stated before, with several of its solvents—it absorbs oxygen with great avidity when a solution of it is exposed to air or oxygen, forming a white crystalline peroxide—1·5 grs. of the hydrocarbon in benzene solution absorbed 60 cc. oxygen in the first minute of its exposure. $C_{38}H_{30}+O_2=C_{38}H_{30}O_2$, it unites directly with chlorine, bromine, and iodine, but in the case of the two former, substitution as well as addition occurs. Hydrogen chloride in benzene solution changes it to hexaphenylethane U.B.

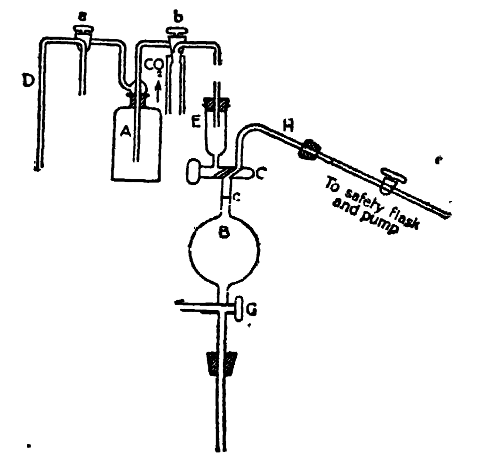


$(Ph=C_6H_5)$

Triphenyl methyl is prepared by reducing a dry benzene solution of triphenylchlormethane with fine zinc shavings. The solution (20 grs. in 100 cc.) is put in the Drechsel washing bottle A, 10 grams of the zinc is added, and the bottle held on its side so that the zinc is spread on the walls; all air is removed by a quick stream of dry carbon dioxide, and the taps *a* and *b* are shut. After a few hours the zinc has sintered together; the bottle is then stood upright and left for five to ten days. The reactions are

$$2Ph_3C \cdot Cl + Zn = C_{38}H_{30} + ZnCl_2$$
$$Ph_3C \cdot Cl + ZnCl_2 = Ph_3C \cdot ClZnCl_2.$$

A is now connected to B, and B is exhausted and



NOTE.—G is a three-way cock, like *a* and *b*. The tube in A goes nearly to the bottom of the bottle.

filled with dry carbon dioxide, these operations being repeated several times. The cocks *b* and C are now turned so that the liquid is drawn from A to B, and the double salt remaining in A is washed with benzene drawn through D into A, then into B. A is now removed, the benzene distilled off under reduced pressure, while B is partly surrounded by rubber tubing, through which steam is blown. B is detached from receiver, and 50 cc. acetone run into B from E, and violently shaken to break up lumps of triphenylmethyl; B is filled with carbon dioxide and apparatus left till cool. Then a suction flask is put on to the rubber stopper below G, and the acetone is sucked off, leaving the crystals in B; the treatment is

repeated with cold acetone. Finally, B is exhausted and filled with carbon dioxide alternately till the product is perfectly dried; it is got out by cutting the tube at *c* and blowing carbon dioxide through. Triphenylmethyl so obtained is very pure, and can even be exposed to air for a while without change. Gomberg has prepared several analogous compounds to this—but not yet in pure condition. Two of the most remarkable are the paratolyl and paranitrophenyl compounds. The former changes spontaneously into the hexaparatolylethane U.B., and it does not take up iodine; its solution is orange inclining to red. The nitro compound gives a remarkable colour display during its formation (molecular silver was used instead of zinc).

Triple Counterpoint (*Music*). Three-part counterpoint written in such a way that all the parts are invertible, each serving as lower, middle, and upper part.

Triple Expansion Engine (*Eng.*) An engine in which the steam is expanded in three cylinders in succession. *See* STEAM ENGINE.

Triple Point (*Heat*). A point on the vapour pressure curve of a substance, at which the substance can exist simultaneously in the solid, liquid, and gaseous states. It is the point of intersection of the curves showing the relation between the pressure and temperature of the solid and vapour, liquid and vapour, and solid and liquid. *See also* VAPOUR PRESSURE *and* SUBLIMATION.

Triplet (*Music*). A group of three notes to be performed in the time of two.

CHOPIN.

It is generally marked by a slur and the figure 3, and may consist of notes, or notes and rests.

Triplet Cycle. *See* TANDEM.

Triple Time (*Music*). *See* TIME *and* TIME SIGNATURE.

Trip Lever (*Eng.*) A bent lever used in trip gear (*q.v.*) One end of the lever is raised by means of a cam; when the cam has passed a certain point, the lever is released and falls suddenly.

Tripod (*Photo.*) A three legged stand for a camera, used in out of door photography where a firm but portable support is required.

Triste (*Music*). Sad.

Tristearin (*Chem.*) *See* STEARIN.

Tristezza, Con (*Music*). With sadness.

Tritone (*Music*). Three tones. Another name for the interval of the Augmented Fourth. It occurs between the Subdominant and Leading Note.

Tritriglyph (*Architect.*) An arrangement of the Doric frieze and intercolumniation such that three triglyphs are used between those immediately above two adjacent columns. *See* TRIGLYPH; ARCHITECTURE, ORDERS OF; ENTABLATURE; MONOTRIGLYPH; *and* DITRIGLYPH.

Triturate (*Chem.*) Grinding substances together so as to facilitate solution or reaction.

Trivalent Element *or* **Radical** (*Chem.*) *See* VALENCY.

Trivet (*Textiles*). *See* TRUVAT.

Trochilus (*Architect.*) *See* SCOTIA.

Trolley *or* **Trolly** (*Elect. Eng.*) A metal wheel or roller attached to the end of a flexible TROLLEY POLE (*q.v.*) on the top of an electric tram or car. The trolley is placed in contact with an electric conductor, in the form of a wire, which extends along the track, supported by standards. The current is conveyed by the trolley to the motor circuit on the car.

—— (*Eng., etc.*) A low built truck or car, generally used for moving heavy materials.

—— (*Lace Manufac.*) A form of lace in which the pattern is outlined with a thickened thread or by a narrow flat border. The ground is generally double with meshes of different shape.

Trolley Pole (*Elect. Eng.*) A pole fixed on the top of an electric car and carrying a conducting wire, which is connected with the motor circuit on the car. To the upper and flexible end of the pole is attached the Trolley (*q.v.*)

Tromba (*Music*). (1) Trumpet (*q.v.*) (2) A reed stop of 8 ft. pitch on Organs. *See p.* 441.

Trombone (*Music*). (1) A brass instrument. *See* MUSICAL INSTRUMENTS, *p.* 437. (2) A powerful organ reed stop of 8 ft., 16 ft. or 32 ft. tone. *See p.* 441.

Trona (*Chem.*) A naturally occurring compound of sodium with carbonic acid having the formula $Na_2CO_3 2NaHCO_3 . 3H_2O$. It is obtained artificially by boiling a solution of sodium bicarbonate for a short time only. On cooling the salt crystallises out.

—— (*Min.*) A hydrous sodium carbonate and bicarbonate composition; soda = 37·8, carbonic acid = 40·2, water = 22 per cent. Mono-symmetric. Grey or yellowish. From Mexico and near Fezzan, in Africa, in both of which localities it is worked commercially.

Tropæolins (*Chem.*) Azo dye stuffs. The chief are:

TROPÆOLIN D, $\begin{array}{l} N \overset{(1)}{—} C_6H_4SO_2ONa(4) \\ \| \\ N \overset{(1)}{—} C_6H_4N(CH_3)_2(4) \end{array}$, is the sodium salt of dimethylamidoazobenzeneparasulphonic acid. It is commonly called METHYL ORANGE (*q.v.*), or Helianthine, and is used as an indicator. *See* INDICATORS.

TROPÆOLIN OO, $\begin{array}{l} N \overset{(1)}{—} C_6H_4SO_2ONa(4) \\ \| \\ N \overset{(1)}{—} C_6H_4NHC_6H_5(4) \end{array}$, also called ORANGE IV., Fast Yellow, etc., is an orange yellow crystalline solid obtained by diazotising sulphanilic acid and acting on the product with an acid-alcoholic solution of diphenylamine. It is a valuable orange yellow dye for wool and silk.

TROPÆOLIN G is the same as the last compound

except that the sulphonic acid group occurs in the meta-position, and it dies a yellower shade.

TROPÆOLIN O, $\begin{array}{l} N \overset{(1)}{-} C_6H_4SO_2ONa(4) \\ \| \\ N \overset{(1)}{-} C_6H_3 \langle {OH(2) \atop OH(4)} \end{array}$ also called RESORCIN YELLOW, is a yellowish brown solid. The free acid is nearly black, and has a green lustre. It is obtained by diazotising sulphanilic acid, and acting on the product with resorcin (*q.v.*) It dies wool and silk a golden yellow.

TROPÆOLIN OOO No. 1, $\begin{array}{l} N^{(1)}C_6H_4SO_2ONa(4) \\ \| \\ N^{(1)}C_{10}H_6OH(4) \end{array}$ (ORANGE I. *or* NAPHTHOL ORANGE), is a reddish brown powder. The free acid resembles the preceding. It is obtained by diazotising sulphanilic acid and acting on the product with α-naphthol. It dyes wool and silk orange.

TROPÆOLIN OOO No 2 (ORANGE II.) is a bright orange colour. The free acid crystallises out the same colour, but is red when anhydrous. It is obtained in the same way as the preceding compound except that β-naphthol is used instead of α-napthol (*see* NAPHTHOLS), so that the hydroxyl occurs at (2) in the naphthalene ring. It is a very important orange dye, and dyes a brighter colour than ORANGE I.; further it is not acted on by alkalis.

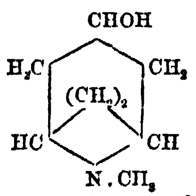
Tropical Year (*Astron.*) The period from one vernal equinox to the next; it is nearly equal to 365¼ mean solar days (*q.v.*) *See also* YEAR.

Tropic of Cancer (*Astron.*) The northern of the two circles on the celestial sphere whose distance from the equator is 27° 27′ 30″. equal to the obliquity of the ecliptic. This northern circle touches the ecliptic at the sign *Cancer*, hence the name. The sun's annual path is by these two circles. *See also* TROPICS.

Tropic of Capricorn (*Astron.*) The southern of the two circles referred to under TROPIC OF CANCER. It touches the ecliptic at the sign *Capricorn*, hence the name. *See also* TROPICS.

Tropics (*Astron.*) Strictly speaking, the two parallels of latitude 27° 27′ 30″ N. and S. of the Earth's Equator. In ordinary usage the word is applied to the whole region lying between these two parallels of latitude: the region is more correctly termed the Torrid Zone. These N. and S. parallels are termed the Tropic of Cancer and of Capricorn respectively.

Tropine (*Chem.*)



A white crystalline solid (plates); melts at 63°; boils at 229°; soluble in water and in alcohol, less soluble in ether. It contains two asymmetric carbon atoms (those adjacent to nitrogen in the ring), but it is not known in an active form, probably owing to a form of internal compensation. It exists in the cis- and trans- forms (*see* STEREOISOMERISM), the second form being known as ψ-tropine. Tropine and ψ-tropine can be converted into each other by oxidising them both to tropinone, the corresponding ketone. This ketone on reduction with sodium and alcohol gives ψ-tropine, and on reduction with zinc dust and hydroiodic acid yields tropine. ψ-tropine melts at 108° and boils at 240°. The tropines are tertiary bases and secondary alcohols. Their acid esters are called tropeines. The formula for tropine shows that it contains: (1) A pyridine ring; this is shown by the fact that ethyl pyridine can be prepared from it. (2) A pyrrole ring; this is shown by the fact that tropinic acid (*see* PYRROLE) can be prepared from it. (3) A seven carbon atom ring; this is shown by the fact that an unsaturated ring hydrocarbon tropilidene, which is cycloheptatriene,

$$\begin{array}{l} CH_2 - CH = CH \\ \qquad\qquad\quad | \\ \qquad\qquad\quad CH, \\ \qquad\qquad\quad \| \\ CH = CH - CH \end{array}$$

can be prepared from it, and further tropine has been synthesised from this hydrocarbon. The importance of the Tropines lies in the fact that a number of important alkaloids are closely related to them. *See* ATROPINE, COCAINE, and HYOSCYAMINE. Tropine is prepared by the hydrolysis of atropine or hyoscyamine.

Troppo (*Music*). Too much, as Allegro ma non troppo—Cheerfully, but not too much so.

Trough. A term of wide application, but usually signifying an open shallow vessel.

—— (*Build.*) A rain water gutter under the eaves of a roof.

—— (*Met.*) The CONVERTING POT or fireclay box in which bars of iron are placed for conversion into steel by the cementation process (*q.v.*)

Trousse (*Archæol.*) A case holding a number of small utensils, hung from the girdle, and worn during the middle ages. *Cf.* ETUI.

Trowel. A tool consisting of a thin blade of iron or steel, triangular, oval, or oblong in shape, with a raised handle. Used by bricklayers and masons for spreading and dressing mortar, etc.; by plasterers for finishing off plaster work; and by moulders for smoothing and shaping the sand or loam forming a mould. A gardener's trowel is scoop shaped.

Trowelled Work (*Plast.*) Plastering that is finished with a trowel instead of with a plasterer's float.

Troy. *See* WEIGHTS AND MEASURES.

Trs. (*Typog.*) *See* TRANSPOSE.

Truck. (1) A low built vehicle, tray, platform, etc., running on wheels. (2) A group of two or more pairs of wheels in a frame, used to support one end of a railway carriage or locomotive. *See* BOGIE TRUCK *and under* RAILWAYS.

—— (*Lace Manufac.*) An antifriction roller or bowl; used in conjunction with a "cam," or what is known in weaving as a tappet (*q.v.*)

Trumpet, Tromba (*Music*). (1) A brass instrument. *See* MUSICAL INSTRUMENTS, *p.* 436. (2) A reed stop on organs. *See p.* 441.

Truncated. Cut short; the term is applied commonly to a cone or pyramid the vertex of which has been cut off.

Trundle (*Music*). A roller used in the drawstop action in the organ. *See* MUSICAL INSTRUMENTS, *p.* 439.

Trunk Engine (*Eng.*) An old form of engine in which the piston rod was a hollow tube, termed a TRUNK, passing through stuffing boxes in both ends of the cylinder. The connecting rod was hinged to a pin fixed inside the trunk.

Trunk Hose (*Cost.*) A garment something like a bag in shape covering the person from the waist to the middle of the thigh or the knee, where it was gathered in. Worn during the sixteenth and seventeenth centuries, generally in conjunction with the jerkin.

Trunk Piston *or* **Plunger** (*Eng.*) A piston or plunger in the form of a tube, with the connecting rod hinged to a gudgeon pin inside it. *See* GAS ENGINE, PETROL ENGINE, *etc.*

Trunnion (*Eng.*) The short projecting axle or pivot on which an oscillating cylinder, a heavy gun, Bessemer converter, etc., turns.

Truss (*Eng., Build, etc.*) A framed structure used to support a roof, etc. *See* ROOFS.

Trussed Shaft (*Eng.*) A long shaft which is stiffened by a series of parallel rods, arranged on an imaginary tube-like surface round the shaft, and fixed to it at their ends. As the shaft revolves, the rods which are at any instant in the lowest position are brought into tension, and resist the tendency of the shaft to bend.

Trussing (*Eng.*) Stiffening any structure by means of rods serving as ties and struts.

Truth (*Eng., Build., etc.*) This word is used in many trades to denote accuracy, symmetry, etc.

Truvat *or* **Trivet.** A small instrument fitted with a sharp steel blade used for cutting the loops of hand woven velvet and other Terry fabrics, so as to form pile (*q.v.*) *See also* VELVET.

Try Cocks (*Eng.*) Two small cocks fitted to a boiler, one being above, the other below, the normal water line. They afford a means of ascertaining (approximately) the level of the water if the gauge glass fail to act.

Trying Plane (*Carp. and Join.*) The form of plane used for finishing surfaces that have to be true and straight. *See* PLANES.

Trying Up (*Carp., etc.*) A term equivalent to "trueing up"; shaping a piece of wood so that its surfaces are accurately plane, and its angles are right angles.

Trypsin (*Zoology*). A proteolytic ferment found in the pancreatic juice. It differs from pepsin (*q.v.*) in acting in an alkaline medium.

Try Square (*Eng., etc.*) A SQUARE (*q.v.*) used for testing the accuracy of right angles on a piece of work. It consists generally of a steel blade set in and at right angles to a stock.

T-Slots *or* **Tee Slots** (*Eng.*) Grooves in the table of a planing machine, etc., whose cross section is in the form of an inverted T: the heads of the bolts used for holding down pieces of work on the table are passed into these slots.

T-Square *or* **Tee Square.** A SQUARE (*q.v.*) used chiefly by draughtsmen; it is made of wood, usually pear or mahogany, and has a thin blade, sometimes tapering on one side, and varying in length from 1 to 3 ft., according to the size of drawing board with which it is to be used.

Tuba (*Music*). (1) A reed stop on organs of 8 ft. pitch and heavy wind pressure; also called *tuba mirabilis* and *tuba major.* (2) A brass instrument of the bombardon species. *See* MUSICAL INSTRUMENTS, *p.* 438.

Tube (*Eng., etc.*) A general name for pipe of any description, excepting that made of cast iron.

Tube Cleaner (*Eng.*) A scraper or a brush, on the end of a long thin rod, used for clearing out the tubes of a boiler.

Tube Cutter. A tool by means of which tubing can be cut. The most usual form consists of a curved holder which grips the tube, and a sharp edged circular cutting wheel, which is pressed against the tube and moved gradually round it, making a cut in the metal as it travels.

Tube Drawing (*Eng., etc.*) The process of making tubing by drawing it through a steel plate furnished with holes of suitable size. The closing up of the joint may be effected in this process, or the joint may be brazed or welded previously. Solid drawn tubes are produced either by forcing the metal through an orifice, a mandrel or "triblet" being fixed concentrically so as to produce the bore of the pipe, or else by taking a short, thick cast tube, and elongating it by the process of drawing.

Tube Expander (*Eng.*) A tool used for widening the ends of metal tubing by means of pressure applied to the inside of the tube. Used especially in fixing the ends of boiler or surface condenser tubes in the tube plate (*q.v.*) The holes in the latter are bored out to fit the tube; the end of the former is placed in the hole, and then expanded sufficiently to cause the plate to grip the end of the tube firmly and so hold it in position.

Tube of Force (*Elect.*) Consider an area on which there is a charge of electricity; let lines of force (*q.v.*) be drawn from every point in the boundary of this area; they will form a tubular surface, which is known as a Tube of Force. If the area contain a unit charge, the tube is termed a Unit Tube. The end of a tube of force is an area containing a charge equal in amount but opposite in sign to that on which the tube commenced.

Tube Plate (*Eng.*) The plate which carries the ends of the tubes of a boiler or surface condenser.

Tube Vice *or* **Pipe Vice.** A clamp fixed to the bench, etc., used for holding pieces of tube while being cut or screwed.

Tube Wrench. A form of wrench (*q.v.*) with serrated jaws capable of gripping a piece of pipe firmly, in order to screw it up into a socket, etc.

Tubing (*Eng., etc.*) A term applied in engineering chiefly to pipes of other material than cast iron—*e.g.* wrought iron, steel, brass, copper. It is distinguished as "solid drawn" when made without a seam; if made with a seam, the joint is brazed, welded, soldered, or in some few cases riveted.

Tub Sizing (*Paper Manufac.*) The process of sizing paper, after it has been made, with gelatine.

Tubular Boiler (*Eng.*) A general term for a boiler having a number of tubes. *See* BOILERS.

Tubular Compass (*Surveying*). A compass needle mounted in a tube, and so arranged that it can be read by looking through the tube, as in a telescope, instead of over the needle as usual.

Tubular Compasses. Compasses whose legs are formed of two (or more) pieces, one sliding inside another in the manner of a telescope, so that they can be lengthened at will.

Tubular Girder (*Eng.*) A hollow girder, whose cross section may be either rectangular (Box Girder) or curved.

Tucker (*Cost.*) A piece of linen, lace, muslin, or other light fabric shaped or arranged to cover the neck and shoulders; worn especially during the seventeenth and eighteenth centuries.

Tucking In *or* **Under** (*Foundry*). Ramming the sand underneath the lowest parts of a pattern during moulding.

Tudor (*Architect.*) *See* PERPENDICULAR.

Tudor Flower (*Architect.*) An ornament resembling the fleur-de-lys, used as a cresting in Perpendicular Gothic work.

Tudor Rose (*Architect.*) *See* ROSE.

Tue Iron (*Eng., etc.*) A TUYERE (*q.v.*)

Tuff *or* **Tufa** (*Geol.*) A term originally applied to pumice stone or a similar light porous lava; it is now used of rocks composed of somewhat fine fragments (such as the dust, ashes, and stones from a volcano) which have become more or less consolidated. *See also* AGGLOMERATE.

Tula Work. *See* NIELLO.

Tulip Woods. *See* WOODS.

Tumbler. (1) A kind of spring latch forming part of a lock. It detains the bolt until the key lifts it and sets the bolt free. (2) One of a set of levers from which the heddles (*q.v.*) are suspended in certain forms of loom.

—— (*Leather Manufac.*) A term applied to a drum in which leather is tumbled to soften or retan it.

Tumbler Bearing (*Eng.*) A form of bearing used to support the long shaft which drives a travelling crane. It is movable, and is displaced as the mechanism of the crane passes it, afterwards returning to its original position.

Tumbler Lock. A lock furnished with a set of discs or latches which must undergo some arrangement with regard to each other before the bolt can be moved.

Tumbler Tank (*Plumb.*) A flushing tank fitted with an oblong receiving vessel which is divided by a central cross partition. The receiver is pivoted and fitted in such a manner that when a quantity of water has run into one of the two compartments it tilts and discharges its contents, bringing the other compartment into position to be filled when the operation is repeated.

Tumbling Bay (*Civil Eng., etc.*) A form of weir, used in estimating the quantity of water which passes over itself in any given time. If the water flows over a horizontal edge of breadth b and the depth of water over the edge $= h$, then the total in cubic feet passing over per second is $C\,b\,h^{\frac{3}{2}}$ where C is a constant which may be found by experiment. If the water pass through a V shaped notch, and h be the depth of water above the lowest point of the V, then $Q = Ch^{\frac{5}{2}}$ where C is again a constant determined by experiment.

Tumulus (*Archæol.*) A prehistoric burial mound.

Tungstates (*Chem.*) *See* TUNGSTEN.

Tungsten (*Chem.*) W. Atomic weight 180. (Also called Wolfram.) A rather rare metal belonging to Group VI., Series 10, of the Periodic System. It is steel grey in colour; has a very high unknown melting point (far above that of platinum); specific gravity about 19; oxidised in air only at a red heat; slowly attacked by water containing carbonic acid; aqua regia oxidises it to the trioxide; when finely divided it is dissolved by boiling caustic potash, forming a potassium tungstate and liberating hydrogen. Tungsten occurs as Scheelite (*q.v.*) and as Wolfram (*q.v.*) $\{CaWO_4$ and $2FeWO_4.3MnWO_4\}$ and in some rarer minerals. The metal is obtained from the trioxide by mixing it with sugar charcoal (800 WO_3 : 80C) and heating the mixture for ten minutes in the electric furnace (900 amp. and 50 volts). Tungsten alloys with iron to form tungsten steel, which is very hard and retains magnetism better than ordinary steel. TUNGSTEN TRIOXIDE, WO_3, is a yellow powder; becomes orange when heated; turns greenish on exposure to light (reduction?); insoluble in water and acids; reduced by heating in hydrogen, first to a blue oxide of uncertain formula, next—at dull redness—to the dioxide WO_2, a red brown powder, and at higher temperature still to the metal. It dissolves on warming with solutions of alkaline hydroxides or carbonates forming tungstates. It is prepared from Wolfram by prolonged digestion with hydrochloric acid to extract the iron and manganese—the acid is renewed from time to time and at last a little nitric is also added; from the residue tungstic acid is extracted by ammonia, forming ammonium tungstate, which is crystallised and finally heated when the trioxide remains. Tungsten trioxide is called by mineralogists tungstic acid. CHLORIDES: The hexachloride WCl_6 forms dark violet crystals; melts at 275°; boils at 347°; it is obtained by heating the metal in excess of chlorine in absence of air and moisture. The pentachloride WCl_5 is obtained by distilling the hexachloride two or three times in a current of hydrogen; it melts at 248°; boils at 276°; forms black needles or a green powder. The tetrachloride WCl_4 is a deliquescent grey brown crystalline powder, decomposed by heating into the pentachloride and dichloride; it is obtained by distilling a mixture of the two former chlorides in a current of carbon dioxide. The dichloride WCl_2 is a grey powder obtained by heating the tetrachloride in a current of carbon dioxide. Two oxychlorides, $WOCl_4$ and WO_2Cl_2, are known. TUNGSTIC ACIDS and TUNGSTATES: Tungsten trioxide combines with water in many different proportions to form tungstic acids; it also unites with acid oxides and water to form complex acids such as silicotungstic acids, phosphotungstic acids. Orthotungstic acid, H_2WO_4, is a yellow solid practically insoluble in water and acids, and obtained by boiling the trioxide in caustic soda to form a tungstate, which is then decomposed by boiling with hydrochloric acid. Metatungstic acid is $H_2W_4O_{13}7H_2O$. Paratungstates are derived from the unknown acids $H_6W_7O_{24}$ and $H_{10}W_{12}O_{41}$; many tungstates derived from other acids than these are known. Only a few compounds which find application are described below. SODIUM PARATUNGSTATE, $Na_{10}W_{12}O_{41}28H_2O$, is the ordinary commercial sodium tungstate; it forms white efflorescent crystals and is used to make cotton and linen uninflammable; it is obtained as

a by product in the extraction of tin (*q.v.*) from its ores when these contain tungsten, and it is also made by fusing wolfram with sodium carbonate, extracting the melt with water and crystallising. The tungsten bronzes are obtained by reducing sodium tungstates in various ways, as by heating in hydrogen, or with tin, or iron, or by electrolysis; they have metallic lustre, are insoluble in acids and alkalis, soluble in sodium hypochlorite, and with ammonia and silver nitrate they give silver and tungsten trioxide, but those rich in the trioxide require heating with these reagents in sealed tubes. A blue bronze, $Na_2W_5O_{15}$, is obtained by melting sodium paratungstate and electrolysing with six Grove's cells; it is a good conductor of electricity; the purple red bronze, $Na_2W_3O_9$, is best obtained by melting together 12·6 parts of sodium carbonate and 68·9 parts of tungsten trioxide for about half an hour and extracting the product successively with water, caustic soda, and hydrochloric acid. Potassium only forms one bronze. PHOSPHOTUNGSTIC ACIDS: The various tungstic acids unite with orthophosphoric acid to form a series of complex acids; the existence of acids formed by the union of 12, 16, 20, and 24 molecules of tungsten trioxide with one molecule of phosphorus pentoxide seems to be certainly established. Phosphoduodecitungstic acid ($H_3PW_{12}O_{40}$ + 25 to 30 H_2O) is obtained by dissolving sodium paratungstate (500 grs.) and ordinary sodium phosphate (250 grs.) in water (500 c.c.), boiling, and adding concentrated hydrochloric acid (750 c.c.); the liquid is evaporated to crystallising point, allowed to cool, and shaken with ether. The lowest layer is separated, the ether driven off, and crystallised. It forms nearly colourless efflorescent crystals; soluble in water. It is used as a precipitant for alkaloids, proteids, urea, ptomaines (putrescine and cadaverine especially), and many of the splitting products of proteids such as the diamino-acids and phenylalanine.

Tungstic Ochre (*Min.*) Also called Tungstite and Wolframine. An oxide of tungsten, WO_3; tungsten = 79·3, oxygen = 20·7 per cent. It is of a light yellow colour, usually pulverulent, and occurring as a coating in Wolfram or Scheelite as a result of their decomposition, hence its localities are those of these two minerals.

Tungstite (*Min.*) *See* TUNGSTIC OCHRE.

Tunic (*Cost.*) A garment shaped something like a shirt and worn either inside or outside other garments. The tunic was commonly worn by the Romans of either sex; that of the Roman senator was distinguished by having a broad vertical purple stripe (*latus clavis*) over the breast.

Tuning Fork (*Sound, Music*). A U shaped fork, usually of tempered steel, having a stem projecting from the base of the U which serves as a handle. On being set in vibration (by striking, bowing, etc.) a nearly pure musical tone is emitted; as the pitch of this tone varies only slightly with temperature, a tuning fork is very useful as a standard of pitch, and for many scientific purpose. For musical purposes forks are most commonly tuned to A or C. *See* PITCH (*Music*).

Tunnel (*Civil Eng.*) An underground passage excavated horizontally (or nearly so) in order to accommodate a railway, road, canal, etc. The wall and roof are supported by arched masonry (except in certain cases when the rock can stand alone without support); this masonry, termed the LINING, is usually continued under the floor of the tunnel, forming a complete tubular arch. Drainage is effected by side channels on the floor, or by a culvert running below the formation level; ventilation is effected in long tunnels by shafts, or if these are impracticable (as in the St. Gothard Tunnel) by fans.

Tunnel (*Marine Eng.*) The hollow passage between the engine room and the sternpost, through which the propeller shaft of a steamship runs.

—— (*Mining*). *See* ADIT.

Tunnel Bearings (*Eng.*) Those bearings of a propeller shaft which are placed within the tunnel (*q.v.*)

Tup (*Eng.*) (1) The main mass of iron forming the head of a steam hammer; it carries a steel block on its lower side which forms the actual face of the hammer. (2) A ram.

Turban (*Cost.*) The distinctive headdress worn by men in Moslem countries. It consists of a shawl or scarf, varying in colour, wound round a tarboosh.

Turbine (*Eng.*) A turbine is a motor in which "rotary motion is obtained by the gradual change of momentum of a fluid" (Neilson). It consists typically of a set of fixed vanes or blades, termed GUIDE BLADES, which direct the motion of the fluid so that it impinges upon another set of vanes carried by a revolving axle, the whole mechanism being contained in a casing of suitable form. Turbines may be classified, according to the direction of flow of the fluid, as (1) RADIAL FLOW TURBINES, in which the fluid diverges from the axis (OUTWARD FLOW), or converges to it (INWARD FLOW), and (2) AXIAL FLOW TURBINES, in which the motion of the fluid is parallel to the axis. A third type, or MIXED FLOW TURBINES, includes machines in which a combination of these forms is used.

WATER TURBINES.—These are most commonly radial flow machines, though for a small head of water (*e.g.* less than 30 feet) a parallel flow turbine, such as those of Fontaine and Jonval, is very suitable. The efficiency of these is about 70 per cent. Outward flow turbines are said to be unsteady in action, but their efficiency is higher than the preceding, sometimes attaining 88 per cent. One of the best known forms is that invented by Fourneyron. Inward flow turbines have been designed by Swain, J. Thompson, and others, and have an efficiency in the best examples of nearly 90 per cent.

When the head of water exceeds 100 feet, a different type, the IMPULSE TURBINE, is advisable. In this form the passages are not full of water, as in the ordinary turbine, but the water rushes with high velocity through a series of jets or nozzles and impinges on suitably shaped blades. The Girard turbine has been successfully used under a head of 650 feet. The PELTON WHEEL has vanes formed into pairs of cups or pockets, the jet impinging on the edge separating two cups and dividing into two parts. A Pelton wheel is used at the Comstock mine in Nevada, with a head of over 2,000 feet, the peripheral velocity of the wheel being 180 feet per second. The efficiency may reach 80 to 85 per cent. under favourable circumstances.

STEAM TURBINE.—The steam turbine, though the most modern form of the steam engine in practice, is the most ancient in actual history, the germ of the invention dating from Hero of Alexandria, in the second century B.C. No further invention is recorded until the engine of Branca (1629), in which a jet of steam impinged on a wheel with vanes—a device which is the parent of the modern engine of De Laval. Other inventions are due to Kempeln (1784), Watt

(1784), Sadler (1791), Trevethick (1815), Ericsson (1830), and Perkins (1836); but the steam turbine in practical work begins at the time when the Hon. C. A. Parsons, F.R.S., carried out successful experiments in 1884. An engine of 10 h.p. made at this time to drive a dynamo was in actual work for some years, and is now to be seen in the Museum at South Kensington. This is a parallel flow turbine, having a series of wheels carrying the blades, all being mounted on one shaft, the sets of guide blades projecting inward from the case. The steam passes from one wheel to the next in succession. By the year 1888 a number of parallel flow turbines, all being non-condensing, were in use for driving dynamos, the total horse-power amounting to about 4,000. In 1889 a temporary reversion to the radial flow type was made for reasons associated with the patent situation; in 1892 condensers were added, thereby for the first time rendering turbines comparable with piston engines with respect to steam consumption, and a number of large turbines were built for electric lighting stations at Cambridge, Newcastle, Scarborough, and London.

The most modern steam turbines adopt the method of parallel flow, which has advantages over the radial flow type in simplicity of construction. The general arrangement of the blades in the Parsons turbine is shown in Fig. 1, the moving blades being light, the fixed or guide blades dark.

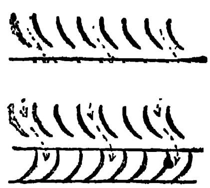


Fig. 1.

Of a different type is the turbine of De Laval, mentioned above. The steam emerges from a series of nozzles and strikes against vanes mounted at the periphery of a single disc (Fig. 2), which revolves at an enormous velocity—*e.g.* 30,000 revolutions per minute in a small engine. The shaft carrying the turbine wheel is flexible, and carries specially designed gear wheels by which the speed is reduced to a suitable amount. De Laval's work was undertaken at just about the same time as Parsons'; and while the De Laval turbine is not built in large sizes, a number of features, notably the diverging nozzle, have been employed in other types, and have had a most important influence on steam turbine development. Other forms of turbine are being rapidly introduced, one of the best known being the Curtis turbine, in which the steam approaches the first ring of blades through inclined nozzles, and afterwards passes through a series of fixed and moving blades alternately. The Curtis turbine has been developed to the widest extent in accordance with vertical shaft designs, with the condenser immediately below the turbine, and constituting an integral part of the machine.

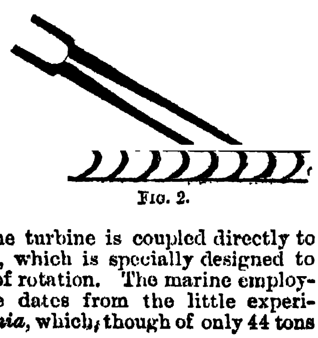


Fig. 2.

The chief applications of the steam turbine up to the present have been to the driving of dynamos and to the propulsion of vessels. In the former case the shaft of the turbine is coupled directly to that of the dynamo, which is specially designed to suit the high speed of rotation. The marine employment of the turbine dates from the little experimental vessel *Turbinia*, which, though of only 44 tons displacement, attained a speed of 34¼ knots. Turbine engines have since been fitted to vessels of larger and larger dimensions, up to ocean liners and battleships, with extremely promising results. Turbine engines have also been applied in various other ways, *e.g.* to the driving of fans and blowers.

Many experiments have been made with a view to applying the principle of internal combustion, as used in gas and oil engines, to the turbine. No practical success has yet been attained, but it is by no means impossible that the difficulties may ultimately be overcome.

Turibulum. A thurible (*q.v.*)

Turkey Red. *See* Dyes and Dyeing.

Turkey Umber (*Dec.*) This name is given to one of the finest qualities of umber because, although mined in Cyprus, it was formerly taken to Constantinople for export. Turkey umber resembles the umbers generally in composition, being chiefly composed of the hydrated oxides of iron and manganese. The fact that the umbers contain considerably more of the latter oxide than the ochres do is the reason of the separation of the two classes, ochres being yellow and umbers brown. Turkey umber has a particularly warm violet brown colour, for which it is highly valued. Its nearest equivalent is probably the Irish umber known as Cappagh brown. It is found that the addition of a little lamp-black to many of the second rate umbers makes them something like Turkey umber, and this adulteration is therefore practised, and has to be guarded against. Like the umbers generally, Turkey, or as it is sometimes called, Cyprus umber, can have various shades imparted to it, in place of its natural colour, by heat. The intensity and duration of the heat are varied according to the result desired; but while the natural warmth of the colour can be enhanced by moderate heat, it is irretrievably lost on overheating.

Turmeric. This consists of the roots of at least two species of plants—*Curcuma longa*, an East Indian plant belonging to the ginger family, and *Canna speciosa*, a West African shrub. In this country, however, all the turmeric is of East Indian origin. The roots come on the market either as "bulbs" or "fingers." The roots are brownish yellow outside and yellow within. The fingers are from 20 to 32 in. long, and the bulbs are sometimes 18 or even 20 in. in diameter, and either spherical or egg shaped. The roots yield on distillation an ethereal oil having a spicy taste and smell. They are sold as such or in powder. In the latter case they are often adulterated with ochre and other mineral yellows, which, however, are at once detected by their great weight when the powder is stirred up in water, or by the amount of ash left on burning a sample. This will not exceed 5 per cent. with genuine turmeric. Turmeric is still to a small extent employed in dyeing textiles, in spite of its looseness both to light and washing. What small amount of use it still finds in this direction is due to the fact that it is a direct dye for wool, silk, cotton, and all other fibres, going on quite as well without a mordant as with one, and that the yellow is very bright. Turmeric can be used to shade faster colours, by which it is afterwards to some extent protected. Like the dye woods, it is used in the form of decoction, but it is wasteful, as the colouring matter known as curcumine is only sparingly soluble, even in boiling water. Turmeric also supplies the chemist with a test paper second in value to litmus paper only. Coarsely powdered

turmeric root is digested in strong spirits of wine for a few days in a warm place. The spirit dissolves out the whole of the curcumine, and assumes a deep orange yellow colour. Blotting paper is soaked in the tincture, and then dried and cut up. The resulting slips are unaffected by acid liquids, but assume a deep chocolate brown when dipped into alkalis. What is still more important, they behave to boric acid as if it were an alkali, and if a solution turns blue litmus paper red and yellow turmeric paper brown, the presence in it of boric acid is practically certain. One illegitimate use of turmeric is to colour mustard which has had its colour diluted by adulteration with starch. The characteristic behaviour of turmeric to alkalis which do not alter the colour of genuine mustard at once betrays the fraud. When powdered turmeric is adulterated with starch, as sometimes happens, a microscopic examination will at once reveal the fact to any one acquainted with the microscopic appearance of starch granules. Again, a very weak solution of iodine in solution of potassium iodide has no effect upon genuine turmeric, but turns a sample adulterated with starch blue immediately.—A. S. J.

Turn (*Music*). *See* ORNAMENTS (*Music*).

—— *or* **Turns** (*Eng., etc.*) *See* TURNS.

Turnbull's Blue (*Chem.*) $Fe''.Fe'''_2\{Fe(CN)_6\}_2$ (Ferrousferric ferrocyanide). A blue solid with a coppery lustre: the air-dried product contains about 28 per cent. of water; insoluble in water and in dilute acids; on heating it gives Prussian blue and ferric oxide; boiled with potash it gives hydrated ferrosoferric oxide and potassium ferrocyanide:

$$Fe''Fe'''_2\{Fe(CN)_6\}_2 + 8KOH = 2K_4Fe(CN)_6 + \{Fe(OH)_2 + Fe_2(OH)_6\}$$

It forms a constituent of commercial Prussian blue. It is obtained by precipitating potassium ferrocyanide with a mixture of ferrous and ferric sulphate, also by adding potassium ferricyanide to an excess of a ferrous salt such as ferrous sulphate—in this case the ferricyanide oxidises a part of the ferrous salt to the ferric salt, and is thereby reduced to ferrocyanide when the reaction becomes the same as before.

—— (*Dec.*) Turnbull's blue was discovered by Gmelin, but it is named after a colour maker who prepared it as his own invention. Turnbull's blue is a pigment suitable for use either as a water or as an iron colour. Its colour, a violet blue, that of Prussian blue having a greenish shade, is not very bright, and is far from permanent, as it turns brown gradually, like Prussian blue, on exposure to the air. It is also expensive to make, as red prussiate of potash from which it has to be made is much dearer than the yellow prussiate. Hence, Turnbull's blue is now rarely used.

Turned Sorts (*Typog.*) When a work or job requires the very frequent use of a particular letter or "sort" it often happens that the stock is prematurely used up, and as a temporary expedient the compositor turns a letter of the same thickness with the foot of the shank upwards and the face downwards, which turned sort is easy to be seen, and is afterwards rectified.

Turner (*Eng., etc.*) A workman employed at the lathe.

Turner Jenny (*Cotton Spinning.*) *See* DOUBLING.

Turnery. (1) The shop in which the lathes are situated. (2) A trade term for various wooden articles produced by turning (*q.v.*)

Turning (*Eng., etc.*) The shaping of work in the lathe. Such work is usually cylindrical in section, but not always so—for example, plane surfaces, whose profile is not necessarily circular, can be produced by the operation of SURFACING (*q.v.*) Turned work varies greatly in nature and in size, from the smallest pivots used in a watch to immense pieces of ordnance or the turntables (*q.v.*) used for railway work. The accuracy obtainable in turning exceeds that which is attained by any other machine tools.

Turning Bar (*Build.*) A CHIMNEY BAR (*q.v.*).

Turning Chisel. A chisel whose cutting edge is oblique, *i.e.* not at right angles to the length or main axis of the tool; used in turning the softer woods in the lathe.

Turning Gouge. A gouge used in roughing out most soft wood when turning, as well as in finishing off concave portions of the work. The profile or outline of the cutting edge is usually rounded off, *i.e.* it forms an arc of a circle, whose radius varies with the size of the gouge.

Turning Moment *or* **Torque.** The MOMENT of a COUPLE (*q.v.*) which acts on a body and produces a tendency to turn. *See also* MOMENT OF A FORCE.

Turning On (*Silk Manufac.*) *See* BEAMING.

Turning Over (*Moulding*). The method of moulding in which each half of the mould is rammed up separately as distinguished from BEDDING IN, in which the lower half of the mould is fixed, the sand being pressed round the pattern from above.

Turnings (*Eng.*) The shavings and fragments removed during turning.

Turning Saw (*Carp. and Join.*) A narrow bladed saw adapted for cutting along a curved line. The name is sometimes applied to a Bow Saw or a Compass Saw (*q.v. under* SAWS).

Turning Tools. For soft wood turning the chief tools are the Turning Gouge and Chisel (*q.v.*) For hard woods other forms of chisel and gouge are used, as well as tools resembling those used for turning the softer metals, such as brass. Metal turning tools are made with stronger blades or shanks, and with cutting edges at an obtuse angle. The actual profile of the cutting edge varies greatly; in the GRAVER and DIAMOND POINT it is triangular or pointed; in ROUND NOSE tools it is rounded; in SIDE TOOLS the cutting edge is on the side, and parallel to the length of the tool; PARTING TOOLS, used for cutting through a piece of metal in the lathe, are very narrow. SLIDE REST TOOLS vary greatly in the form of the cutting edge, but are forged with a square shank by which they are held in the slide rest.

Turning Up (*Bind.*) The process of making the back of a book in boards assume a flat position for the purpose of cutting the foredge; effected by means of trindles. *See* TRINDLE *and* BOOKBINDING.

Turnpin (*Plumb.*) A cone shaped piece of hard wood, used for opening the ends of lead pipes.

Turns *or* **Turn.** An old name for a lathe; still applied to a watchmaker's lathe, which is a small dead centre lathe.

—— (*Music*). *See* ORNAMENTS, *p.* 478.

Turnscrew. A SCREWDRIVER (*q.v.*)

—— (*Typog.*) A small flat piece of steel usually oval in form used for fastening or unfastening the slide screw of a composing stick.

Turnsole (*Botany*). A red dye formed by fermentation of the leaves of *Chrozophora tinctoria* (order, *Euphorbiaceæ*), a native of Grand Gallargues in the south of France; has been used for centuries in the cheese industry in Holland.

Turntable (*Eng.*) A circular revolving platform on which a locomotive, etc., can be placed in order that it may be reversed, or shifted from one line of rails to another. The table has a central pivot, and is also supported at its circumference by wheels or rollers running on a circular ring.

Turn Up (*Plumb.*) The part of a lead or zinc gutter turned up so as to rest against the wall.

Turpentine (*Dec.*) The word "turpentine" is used in two senses. It may either mean the crude exudation of certain coniferous trees or the more volatile products of the distillation of these exudations. The latter is more properly called oil or essence of turpentine, and it is proposed in this article to deal with crude turpentine and oil of turpentine separately.

Crude Turpentine.—Almost all *Coniferæ* yield this product, but only a few of them yield it in sufficient quantities for commercial exploitation. The chief varieties of crude turpentine, each with its conifer of origin, are as follows:

Name.	Tree of Origin.	Remarks.
	A. COMMON TURPENTINE.	
American	*Pinus palustris* or *australis*, the long leaf or yellow pine	Thickly flowing. Yields up to 17 per cent. of oil of turpentine.
French	*Pinus pinaster* or *maritima*	More fluid than American. Yields up to 25 per cent. of oil.
German	*Pinus sylvestris* " *rotundata* " *nigra* *Picea vulgaris*	Semi-fluid, tough and sticky with an unpleasant smell. Completely soluble in alcohol. Yields up to 30 per of oil.
	B. RARER TURPENTINES.	
Venice	*Larix decidua*	Milky when first drawn but clears soon afterwards. It is colourless or brownish, bitter and with a not unpleasant smell. Dries slowly. Yields from 18 to 28 per cent. of oil.
Hungarian	*Pinus pumilio* or *nigricans*	Clear. Pale yellow and thin and with a hot aromatic smell and taste.
Carpathian = Cedar Balsam	*Pinus cembra*	Thin, colourless, and smelling like juniper. Taste bitter and spicy.
Strassburg	*Abies alba* or *pectinata*	Very thin, yellow or brown, and dries easily. Very bitter and with a lemon-like smell. Not wholly soluble in alcohol. Yields about 25 per cent. of oil.
Canada Balsam	*Abies canadensis* or *balsamea*	Thin, pale yellow, with a pleasant smell and sharp aromatic taste. Dries rather slowly.
Cyprus or Chian Turpentine	*Pistacia terebinthina* and *P. vera*	Clear or slightly turbid, and of a greenish yellow colour. The taste is spicy, and the smell resembles that of fennel. It is fully soluble in ether.

Turpentine is obtained by cutting into the wood through the bark. The resin which then exudes is collected either in a cavity scooped out in the tree itself or in a pot or other vessel fixed to the tree in such a position that the liquid will flow into it. The collection of the turpentine generally takes place all through the summer, but spring is the harvest time in North America. The exact method of cutting the trees varies greatly. In many places the cuts are made on either side of an imaginary line drawn vertically on the trunk and inclined towards the line so that the exudations from all the cuts will meet and pass to a common receiver. It is of great importance, however, that the turpentine should be frequently collected and, if not at once distilled, put into receptacles where it is shielded from the air. Exposure to the air gradually hardens and coagulates the turpentine, and as this hardening takes place solely from the resinification of the oil, it means loss of the most valuable constituent of the raw product.

The period during which a tree can be tapped varies considerably, and depends a good deal upon the age of the tree when the tapping was commenced. It probably averages about twenty years. In France, where the exploitation of turpentine is very scientifically carried out, the trees are first tapped when about twenty-five years old, and are usually exhausted in twenty years, although there are instances of much more prolonged vitality. In America the state of affairs is practically the same. The annual yield of a tree may be put as averaging 15 to 16 lb. per annum.

OIL OF TURPENTINE.—This is prepared by distilling crude turpentine with water until no further distillate passes over. In the condensers the oil floats on the top of the water, and is therefore easily separated from it. The residue in the still is resin or colophony, which is either used in this form or is separated into resin oils and pitch by another distillation at higher temperatures.

Oil of turpentine is mainly a mixture of various terpenes, and varies in its nature according to the tree from which the crude turpentine was obtained. The terpenes are polymers of C_5H_8, some having the

formula $C_{10}H_{16}$ and some $C_{15}H_{24}$. Their chemical constitution is practically unknown, but they are numerous, and no two oils of turpentine agree in the terpenes they contain, although in most cases this difference does not affect the practical employment of the oil. The following are some particulars about the turpentine oils most largely used:

American.—This has an average specific gravity of from ·86 to ·87. It is nearly always dextrorotatory, but in some cases it is slightly lævorotatory. It boils at about 158° C., and almost the whole (90 per cent. at least) should distil below 165°.

French.—Practically the only difference between this and the American oil is that the French product is invariably lævorotatory.

German.—This is again dextrorotatory, with about the same gravity, but a somewhat higher boiling point than the American oil.

Russian.—Russian oil of turpentine is the heaviest of all, having a specific gravity approaching 0·875 or even 0·88. It is dextrorotatory, and boils between 170° and 175° C. Its disagreeable and persistent smell is a great bar to its use. Were it not for this its cheapness would secure for it a far larger consumption.

The chief use of oil of turpentine is for thinning oil varnishes. It is impossible to thin them with oil, as the time of drying would thereby be unduly lengthened. Turpentine oil thins the varnishes till they can be easily applied with a brush without precipitating them, and as it is volatile the diluted varnish dries as quickly as the undiluted. Turpentine oil is also used to some extent in medicine in the treatment of bronchitis, and as an anthelmintic, as well as externally as a rubefacient. The pharmaceutical terebenum is prepared by the treatment of rectified oil of turpentine with sulphuric acid. The acid destroys the optical activity of the oil, whether it is dextro or lævorotatory, and is then removed by repeated washing with water.

The chief adulterants of oil of turpentine are petroleum and resin oil. Both are easily detected on distillation. If the oil does not begin to boil below 155° C., and leaves practically no residue after prolonged exposure to a temperature of 165°, it may be considered pure. Oil of turpentine is itself employed as an adulterant of many essential oils. It may be mentioned, in conclusion, that the separation of oil of turpentine from the natural resin exuding from pine trees is an operation at least 1,200 years old. It is mentioned by Marcus Græcus in the eighth century in a work entitled *Liber ignium ad comburendos hostes.* This may be rendered "A work on fires for burning up your enemies."—A. S. J.

Turpeth Mineral (*Chem.*) A basic sulphate of mercury formed by boiling mercuric sulphate (*see* MERCURY COMPOUNDS) with water; it is a yellow powder sparingly soluble in water.

Turquoise (*Min.*) A hydrous phosphate of aluminium with a low variable percentage of cuprous oxide. Usually reniform or encrusting. Colour, the blue of the same name. From India, Thibet, Arabia, Persia, etc. It is used extensively as a precious stone. *See* PRECIOUS STONES.

Turret (*Architect.*) A small tower. A turret containing a stair is frequently attached to the main tower of a church.

—— *or* **Capstan** (*Eng.*) A form of rotating tool holder carried on a slide rest. A number of tools are fixed in the holder, and any one of these can be brought into action at will, thus enabling a number of operations to be carried out in succession on the same piece of work. The use of a turret greatly facilitates the production of repetition work.

Turret Lathe. A lathe fitted with a TURRET *or* CAPSTAN (*q.v.*).

Turwahr Bark (*Leather Manufac.*) This is the bark of a species of acacia (*Acacia auriculata*) used in India for tanning sheepskins.

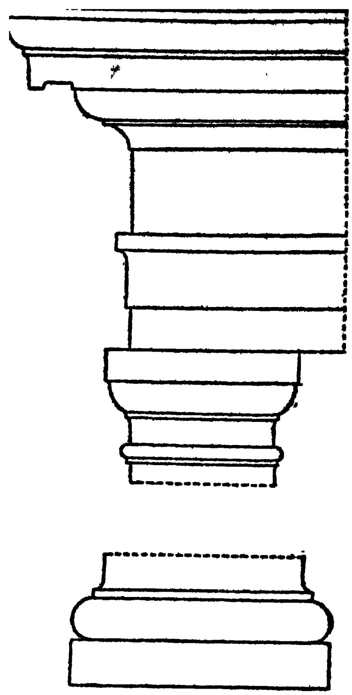
Tuscan Order. A modification of the Doric order used by the Romans. *See* DORIC *and* ARCHITECTURE, ORDERS OF.

Tusk Tenon (*Carp. and Join.*) A form of tenon used in large framing, having the form shown in Fig. 5, p 754 (*art.* TENON).

Tutti (*Music*). All; full.

Tuyere *or* **Twyere** (*Eng., Met., etc.*) The nozzle or jet through which an air blast enters a furnace or fire. The name is also spelled TUER, TWEER, *and* TUE IRON.

Twaddell Degrees. *See* HYDROMETER.



TUSCAN ORDER.

Twaddell's Scale. *See* HYDROMETERS.

Tweezers (*Typog.*) Small pincers of spring steel with fine pointed jaws used for extracting a type from a line or page of matter.

Twelfth (*Music*). (1) An organ stop sounding the interval of a twelfth above the note played. (2) The interval of the double fifth.

Twelvemo *or* **Duodecimo** (*Print., etc.*) A sheet of paper folded so as to form 12 leaves (24 pages); generally written 12mo. A book made up of sheets folded in this manner. *Cf.* OCTAVO, QUARTO, SIXTEENMO.

Twentyfourmo (*Print., etc.*) A sheet of paper folded so as to form 24 leaves (48 pages); generally written 24mo. A book (of small size) made up of sheets folded in this manner. *Cf.* OCTAVO, QUARTO, TWELVEMO.

Twilight (*Astron.*) The illumination of the upper air after the sun has set. It continues so long as any portion of this illuminated air remains in sight of the observer. Caused by reflection of sunlight from upper portion of the earth's atmosphere.

Twill (*Textile Manufac.*) A simple type of weave, resulting in a fabric with fine lines or ribs traversing the cloth diagonally from selvedge to selvedge. Broad classification is that of warp and weft twills, in which the warp and weft respectively make the face of the cloth.

Twin Crystals (*Min.*) Crystals, the two halves of of which show a rotation from the normal of 180° in a plane known as the twin plane (*q.v.*) Sometimes the crystals appear to penetrate one another; they are then known as Interpenetration Twins.

Twinkling of Stars (*Astron.*) *See* SCINTILLATION.

Twin Plane (*Min.*) An imaginary plane in a twinned crystal which is either parallel to a possible face or normal to a possible zone axis, of each of the members of the twin system, and is such that if one half of the twin system were revolved in that plane through two right angles, it would occupy the place of the other half. *See* SYSTEMS OF CRYSTALS.

Twin Screws (*Eng.*) A pair of screw propellers, one being placed on each side of the sternpost of a steamship. They are right and left handed, and are rotated in opposite directions when the vessel is steaming straight ahead.

Twist. Turning, convolution, or flexure. The term is also used loosely to include torsional stresses and strains.

—— (*Textiles*). *See* YARN.

Twist Bits (*Carp. and Join.*) Bits having a thread and cutters at the end, and twisted in their length. *Cf.* TWIST DRILL.

Twist Cop (*Cotton Spinning*). *See* COP.

Twist Drill (*Eng.*) A drill having a cylindrical body or shaft with two (or more) grooves of helical or screw shape running round it. It is the best form of drill for almost any purposes. The end of the drill is accurately ground to a conical shape, and the cutting edges are formed by the intersection of this conical surface with the grooves.

Twist Drill Grinder (*Eng.*) A machine in which a twist drill is held and pressed against a revolving emery wheel, in order to produce a truly conical point whose axis coincides with that of the shaft or body of the drill.

Twister (*Textile Manufac.*) A machine on which fancy yarns are obtained by folding two or more threads together.

Twist Hand (*Lace Manufac.*) A workman employed in any description of twist lace; a lace maker.

Twisting (*Silk Manufac.*) The process of joining a new warp to the thrum (*q.v.*) in the loom, the threads being played out one by one on the cross rods and joined with a twist by finger and thumb. *Cf.* TWISTING IN.

Twisting In (*Weaving*). An alternative process to drawing in. Attaching the threads of a new warp to the ends of a finished warp which have been previously drawn through the healds or harness mails.

Twisting Moment. TORQUE *or* TURNING MOMENT (*q.v.*)

Twist Lace (*Lace Manufac.*) Lace made upon what is usually known as Nottingham lace machinery, after Heathcote and Lever's principles, in which bobbins and carriages are employed. *See* LACE MANUFACTURE.

Two High Mill *or* **Rolls** (*Met.*) A rolling mill consisting of two rolls, one above another. *See* ROLLS.

Two Line Letters (*Typog.*) Letters of the depth of two lines of type and used as initials. *See* TYPES.

Two Salt Water. Water in which the amount of dissolved salt is double that of normal sea water. This is the highest degree of concentration which the water in a marine boiler should be allowed to reach.

Two Throw Crank (*Eng.*) A shaft with two cranks forged or fixed upon it, the cranks usually being at 90° with each other.

Two Tone (*Lace Manufac.*) A term appplied to lace composed of cotton of the natural colour (ecru) interspersed with objects of white.

Twyere *or* **Tuyere** (*Eng., Met., etc.*) *See* TUYERE.

Tympan (*Print.*) A thin iron frame covered with parchment on which the sheet of paper to be printed is placed. *See* TYPOGRAPHY.

Tympan Hooks (*Print.*) Small hooks fixed on the upper side of the outer tympan of a press. *See* TYPOGRAPHY.

Tympani *or* **Timpani** (*Music*). The kettledrum. *See* MUSICAL INSTRUMENTS, *p.* 444.

Tympan Joints (*Print.*) The joints by which the outer tympan is attached to the carriage of a press on which it works. *See* TYPOGRAPHY.

Tympanum (*Architect.*) The space enclosed between the horizontal and raking cornices of a

TYMPANUM.
Essendine Chapel, Rutland.

classical pediment. Similarly, the space between the flat head of a door opening and the arch over.

Tymp Arch (*Met.*) The arch over the opening in the front of the hearth of a blast furnace.

Tynes (*Her.*) The small branches projecting from the antlers of a stag.

Typefounding may be said to date from the time when the early German typographers invented the system of cutting separate punches for each letter or character, and driving the punch into a piece of hard metal, thereby forming the matrix, which was adjusted to one end of a mould, and

types cast therefrom—the body or shank of the type being formed by the mould, and the letter or face by the impression of the punch. Types were originally cast by "hand mould." The operator held the mould with the matrix adjusted in his left hand, and by means of a small ladle poured in a sufficient amount of molten metal to form the type, which was released when the upper and lower sections of the mould were separated.

The art of Typefounding consists of several processes: (1) Designing the face, (2) Cutting the punch, (3) Striking or "growing" the matrix, (4) Justifying the matrix, (5) Mixing the alloy, (6) Casting the type, and (7) Dressing and finishing the product. In designing the face it is necessary that the artist be acquainted with the special requirements of the printing trade and the proportions of each letter in the fount to be produced. The different parts which form the characters must be in strict relation to each other. The cutting of the punch requires patience, artistic skill, and minute attention to details. Steel which has been annealed to allow of easy working is used, and it is afterwards tempered to overcome the resistance of the subsequent driving. The punch may be called a type in steel, the engraved end being tested by minute callipers and gauges to verify the width of the body strokes, the fineness of the cross strokes and the curves and lengths of the ears and serifs, which are subject to certain scales of proportion. A counter punch is sometimes used to form the open space within the letter "O," it being easier to form this hollow by a punch than by the process of engraving. The matrix, which is a small rectangular piece of copper, with one side highly polished, is fixed in a block and the punch driven in by means of a hammer at a point near the top and with equal space at the sides. A small burr in the copper is caused by this operation; this is smoothed off and the impression is mathematically adjusted for the purpose of securing proper alignment and uniform height of all the characters in the fount of type. Matrices are also obtained by a process of electrotyping whereby a large number may be "grown" at one time.

THE PUNCH.

Types are usually cast in an alloy, of which the ingredients are lead, antimony, and tin, the proportions varying according to the size and quality of the letter required. Lead gives ductility to the alloy, antimony the required hardness and sharpness, and tin gives toughness and a finer grain to the mass. Antimony expands in cooling, and thus further assists in the production of a perfect type. A trace of copper is sometimes incorporated. The proportions of a good alloy are: Lead, 48 per cent.; antimony, 25 per cent.; tin, 25 per cent.; copper, 2 per cent.

THE MATRIX.

The hand mould is practically obsolete, but is used occasionally for casting special characters. Similar in principle is the machine mould, which consists of a number of pieces of hardened steel fitted with the utmost mathematical accuracy. It is constructed to open in halves, which separate and release the type when cast. The matrix is fixed in position by a bow spring over the orifice of the mould. Molten metal is injected by means of a pump. As the wheel of the machine revolves, the mould is presented to the nozzle of the pump, receives a charge, and returns with a fully formed type, which is discharged and the operation repeated. An important function of the mould is to form the nicks, which distinguish the many founts of different faces. There may be one or more nicks, and they are caused by fixing into grooves on the front of the mould small pieces of steel wire. Another piece of wire is placed in a drilled hole in the upper body to form the pin mark, which is used for discharging the type after it is cast.

Attached to the body of the type as it leaves the mould is a piece of surplus metal called the "jet," which may be detached automatically at the moment of discharge or be broken off by hand. This is the first necessary process in finishing. The types are then rubbed on the surface of a rough stone to remove any "rag" or burrs arising from an imperfect mould or badly fitted nicks, and afterwards set in lines on narrow wooden sticks. The line is inverted and the break of the jet removed by passing a groove over its whole length. The fronts and backs of the letters are scraped, and the types restored to a face-up position, examined with a lens, and all imperfect letters rejected. In cases where a portion of the face overhangs the body of a type, as in the letters *j* and *y*, kerning is necessary, and this is effected by rubbing the side of the body on which the projection shows along the face of a bevel edge file. By the old hand-casting process a man could produce from 2,000 to 3,000 types in a day. The average machine output is nearer 50,000. Perfecting machines are in use which cast and break off the "jet" of the type, finish, and arrange them in line ready for making up into page. A machine which casts and finishes types still more rapidly is the Wick Rotary Type-casting Machine. This consists primarily of a horizontal wheel with channels on its surface radiating from the centre. In each channel is a sliding piston having a matrix on its end nearest the outer edge of the wheel. The channels are covered with a disc, and thus present a series of openings in the periphery of the wheel corresponding with the size of the types to be cast. As the wheel revolves, these openings pass in succession before a minute opening in the mould through which a constant stream of molten metal is being forced by pumps. When the mould has passed the nozzle, the pistons push out the finished type on to a travelling chain at the rate of about 50,000 an hour.

TYPE WITH JET.

Type High (*Typog.*) The height of a type. The term is used in connection with the mounting of stereo, electro, and engraved plates for use with type.

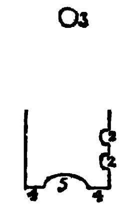
Type Holder (*Bind.*) An implement for holding the metal type when set up for lettering labels or the back and sides of books. *Cf.* HAND LETTERS.

Type Metal (*Chem.*) An alloy of lead, antimony, tin, and occasionally copper. It expands on solidifying. It is used in type founding. Type metals vary a good deal in the proportions of their constituents, *e.g.*:

	I.	II.
Lead . . .	50	82
Antimony . .	25	14·8
Tin . . .	25	3·2

See also TYPEFOUNDING *and* TYPES.

Types (*Typog.*) The letters or characters used in printing. They are generally cast in an alloy of lead, tin, and antimony. In some cases a small percentage of copper is added. They vary in size from the *Minikin* (about 20 lines to the inch) to the large poster series, and the number of faces is infinite. The standards of English founders differ; but the practical base from which all sizes are regulated is the *Pica*—one-sixth part of an inch in depth of body from back to front. The introduction of the Point System has removed many disadvantages arising from lack of uniformity in English bodies. There are 72 points to the inch, and the following table shows the comparative relation of one system to the other in the more important founts:

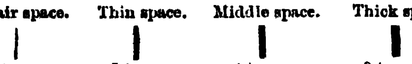


1. The shank or body.
2. The nicks.
3. The pin mark.
4. The feet.
5. The groove.
6. The front.
7. The back.
8. The shoulder.
9. The bevel.
10. The face.

	Points.	Approximate lines to foot.	Pica Ems.
Diamond	4½	192	From the Euphrates, Abraham, not without divine guidance, wanders towards the West. The desert oppos
Pearl	5	173	From the Euphrates, Abraham, not without divine guidance, wanders towards the West. The des
Ruby	5½	157	From the Euphrates, Abraham, not without divine guidance, wanders towards the West. T
Nonpariel	6	144	From the Euphrates, Abraham, not without divine guidance, wanders towards
Minion	7	123	From the Euphrates, Abraham, not without divine guidance, wanders towa
Brevier	8	108	From the Euphrates, Abraham, not without divine guidance, wanders
Bourgeois	9	97	From the Euphrates, Abraham, not without divine guidance, wa
Long Primer	10	86	From the Euphrates, Abraham, not without divine guid
Small Pica	11	78	From the Euphrates, Abraham, not without divine
Pica	12	72	From the Euphrates, Abraham, not without
English	14	62	From the Euphrates, Abraham, not
Great Primer	18	54	

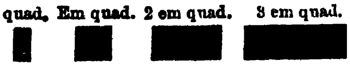
The next sizes in their order are Double Pica, Two line Pica, Two line English, Two line Great Primer, Two line Double Pica, and Canon, which is the last to have a distinctive name. The larger sizes are designated according to the number of picas contained in the depth of body. The *Spaces* and *Quadrats*, used for separating words and filling up blank spaces, are proportionate in thickness to the em of the body:

*Hair space. Thin space. Middle space. Thick space.



8 to em. 5 to em. 4 to em. 3 to em.

En quad. Em quad. 2 em quad. 3 em quad. 4 em quad.



*When founts are cast on the unit set system the types as well as the spaces have the same proportionate relation to the em. The height of a type from the bottom of its feet (4) to the surface (10) is $\frac{9}{10}$ of an inch, or about the diameter of the English shilling.

Type Setting Machines. Those now in use are for the most part improvements on different machines patented by Hattersley, Mackie, and others about the middle of the nineteenth century. Two were in operation in Hull during the year 1862. Ordinary founders' types were used, and the lines were justified by hand. The THORNE machine, which is of this class, composes movable types specially nicked. The types are assembled continuously, and divided into lines of required width by a person who sits near the operator of the machine, which consists of a keyboard and two vertical cylinders. The cylinders are upon the same axis, and are placed one above the other. The surfaces of these cylinders contain a number of channels about an inch deep, running the whole length. The upper cylinder revolves, and has an attachment regulating the distribution of the type. Every channel in this cylinder being filled with lines of mixed type, it is made to revolve, and each type drops as it comes in contact with the groove in the lower cylinder corresponding to the nicks until the various channels are filled. When keys on the board are depressed the corresponding type are transferred from the lower cylinder to a point where they are conveyed by a travelling band to a setting stick and galley for the purpose of being justified. The MONOTYPE machine casts separate types, and assembles and justifies them automatically in successive lines. It is constructed in two parts, *viz.* a keyboard and a casting machine. The keyboard, operated independently, consists of a number of keys corresponding with the characters in the die case of the casting machine, a set of punches, and a registering attachment. As the keys are worked the punches, acted on by compressed air, perforate a roll of paper in special positions, so that when the roll is transferred to the casting machine the perforations regulate the matrices conforming with the letters punched, and bring them into position for casting. At the same time as the perforation is effected, the scale action, previously set to the width of the line required, registers the letters as composed, and towards the end of the line a bell is rung. The operator may then, by depressing keys indicated on the register drum, perforate the necessary spacing for filling out the line. When the roll of perforated paper is transferred to the casting machine it brings the required matrix into position over the mould, through which the metal is pumped. The types are cast in a vertical position, and ejected continuously until a line is completed. It is then drawn off to a galley, the carrier returning to receive successive lines as completed. The LINOTYPE machine, as its name implies, produces a "line-o'-type" instead of separate characters. It consists of three parts in one combination: (*a*) The mechanism for assembling the matrices by the manipulation of the keyboard;

(*b*) the casting apparatus which produces the slug or line from the assembled matrices; and (*c*) the arrangement for distributing the matrices into their respective magazines after the line has been cast. These operations are performed concurrently, *i.e.* the matrices used for the first line are being distributed while those for the second are being cast and those for the third are being composed. The depression of a key releases a matrix from its position in the magazine, which contains all the characters assorted in sloping channels. It is then assembled with others in order of copy until the necessary number of words for a line is completed. The words are separated by space bands consisting of two steel wedges, the outer edges of which are always parallel. The completed line is moved to the elevator and thence to a vice, where the matrices are brought into alignment, and locked against and across the face of the mould. The metal is then forced into the mould, which has already been set to cast the slug in the required length and thickness. It is afterwards mechanically trimmed and delivered to a galley. The discarded matrices are carried by the elevator to the top of the magazine. Over this is fixed a distributor bar with ribs to engage the teeth of the matrices, which slide along until each reaches the mouth of its proper channel. The ribs of the bar being in harmony with the teeth of the matrix, its release is compelled. The MONOLINE machine differs in design and construction from the Linotype. Its output is, however, similar. The machine consists of a keyboard, magazine for matrices, and automatic justifying spacers, a casting well, delivery attachment, and distributing mechanism. The magazine contains 500 matrix bars, each having twelve *intaglio* letters on its front edge. These bars stand behind each other in channels, and are assembled in accordance with the action of the keyboard in lines. The operator moves a lever on the keyboard, and the machine automatically justifies, casts, and delivers the lines on to a galley, and the matrix bars and spaces are returned to the magazine.

Typhoon (*Meteorol.*) Cyclones in the torrid zone in their greatest development are called typhoons or hurricanes. They vary from a few miles to several hundred miles in diameter, and are accompanied by great winds and torrential rain. *See* CYCLONE.

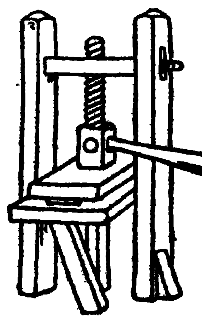
Typography. The art of setting up types and taking impressions from them. The evolution of modern Typography may be traced from the invention of movable types, the secret of which, according to Hadrian Junius, was discovered by Laurent Coster, of Haarlem, and became known to Gutenberg, who in 1439 devoted himself wholly to the art of Typography. Peter Schœffer, working in conjunction with Gutenberg and Fust, invented a method of casting types. These were used in 1454, and the first complete book, the Gutenberg Bible, was issued in 1456. The art was introduced into England in 1476 by William Caxton, who practised it in the precincts of Westminster, using what is known as Black Letter type. Of the notable works produced, *The Dictes and Sayings of the Philosophers* (probably the first book printed in England) and *The Game and Playe of Chesse*, printed in 1474, may be mentioned. Roman types were first used by Wynkyn de Worde, of Lorraine. Later on Typography spread to various towns, notably to Oxford in 1478, and to St. Albans in 1480. Little progress was made in England during the sixteenth century. The first English Bible printed in Roman type was produced in Edinburgh in 1576. On the Continent, Christopher Plantain, of Antwerp, and the Elzevirs, of Leyden, in Holland, had done much to improve the productions of Typography. Printing was established in the North American Colonies during the seventeenth century; but the most famous of its exponents in that part of the world, Benjamin Franklin, was not born until 1706. Previous to 1720, English printers obtained their best types from the Dutch founders, but with the advent of Baskerville and William Caslon a marked advance in English manufacture was begun. To the fine character of the types cast by the latter may be attributed much of the perfection of modern book printing. Caslon commenced casting types for Cambridge in 1750. The early years of the nineteenth century witnessed still further improvement. The eager demand of collectors was the cause of many sumptuous works being produced, almost regardless of cost. About 1830, Charles Whittingham, of the Chiswick Press, by the introduction of headpieces, tailpieces, borders, and other typographical ornaments, effected a revolution in style, and to him and the publisher, William Pickering, is due the inception of "old style" printing. The improvements in the character of types and typographic ornaments, as well as developments in wood engraving, paved the way for the introduction of illustrated periodicals, of which the modern magazine is the outcome. To Mr. Theodore De Vinne, an American printer, may be attributed much of the excellence of modern Typography. He has consistently advocated a high standard of beauty and purity in type faces, and he has also considerably advanced the mechanical processes by introducing the system of printing on dry paper—a necessary condition in the reproduction of photographic process blocks, which have almost entirely superseded wood engravings. Prior to the introduction of type setting machines (*q.v.*), little, if any, change was made in the actual process of *Composing* type. Until about the middle of the nineteenth century the compositor used almost exclusively the same methods and tools as his early predecessors. Any departure was in the direction of "display" or "jobbing work," which the use of complicated ornaments and "fancy" types made possible, and the cultivation of "style" encouraged. Hand composition is accomplished practically on the original plan. The types are "distributed" one by one into shallow cases containing divisions or boxes to hold each character. These cases, which are usually in pairs for ordinary Roman founts, are "put up" on frames in a sloping position. The upper case contains 98 boxes in all, and into these are put the capital letters, small capitals, figures, signs, and "peculiars." The lower case contains 53 boxes of different sizes. For Hebrew, Greek, etc., the divisions of the cases are varied and more complicated. From the cases the types are picked out as required by the compositor, and placed in the "composing stick," a traylike iron frame. By means of this

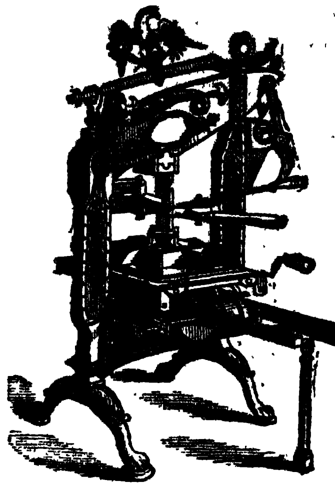
COMPOSING STICK.

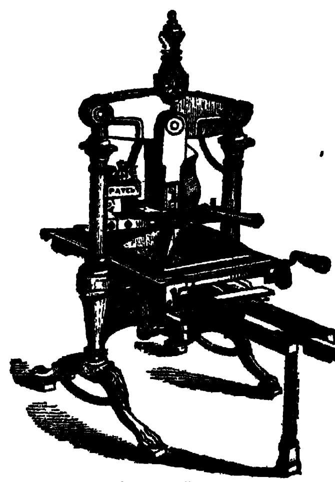
stick the types are arranged in lines, according to "copy." As the stick is filled the matter is lifted on to a galley. "Matter" may be "solid" or "leaded." When the lines of type are close together they are said to be solid, and when opened out, leaded. The leads used

for the purpose are thin strips of metal cut to the full length of the line of type, and of widths varying from $\frac{1}{72}$ to $\frac{1}{24}$ of an inch, the technical terms being 12-to-pica, 8-to-pica, 6-to-pica, and 4-to-pica. The "pica" is one-sixth of an inch. (*See* TYPES.) Leads of a thinner make are sometimes used, and when the strips of metal are thicker than 4-to-pica they are called "clumps." The lines having been spaced and "justified" to equal lengths in the composing stick, they are easily fastened in the galley, and a rough impression obtained on a galley press. This impression, usually termed a "slip" or "first proof," is taken to the reader, whose duty it is to detect and mark all proof corrections (*q.v.*) When the mistakes are corrected, the matter is ready for "making up" (*q.v.*) into pages of the required size. Headlines and folios are added to give the order of pagination. The pages are subsequently "imposed"—that is, laid down upon an iron imposing surface in such order that, when "locked up" and printed on a sheet of paper, the latter may be folded so that the pages follow each other consecutively. The pages are locked up by means of furniture (*q.v.*)—which is arranged in such manner as to give the required margin round the printed pages—and quoins (or wedges) in an iron frame or chase, which in book work usually contains eight, sixteen, or more pages. The combination then becomes a "forme." This imposed forme is now ready for the press. The art of the compositor is not confined to book work. Jobbing and the cultivation of styles of display have opened up large possibilities in the grouping and arrangement of types and lines. Elaborate designs are effected by the use of appropriate ornaments, and the discriminate use of tints and coloured inks in printing materially aid the compositor in producing artistic results. The arrangement of music types, the composition of the Greek and Hebrew languages, tabular matter, and mathematical workings demand no mean degree of mechanical skill and general knowledge.

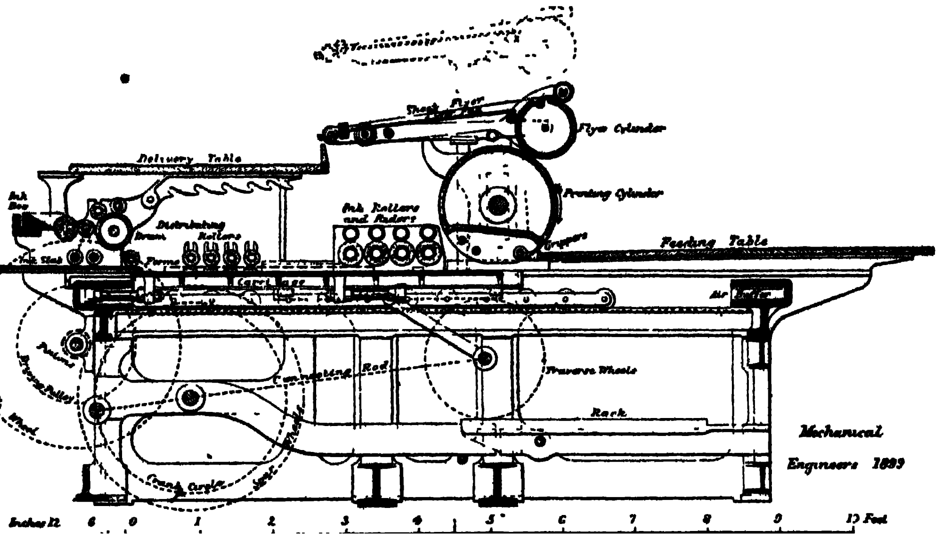
It is in the actual process of PRINTING, or the impressing stage of the art, that marked advancement is to be found, but the more important developments may be traced from a period as recent as the beginning of the nineteenth century. Until that time nearly all printing was done on hand presses, and then only by one or two pages at a time. The first printing press was probably an adaptation of some domestic appliance, the impression being obtained by means of a wooden screw forcing a wooden platen on to the forme, which was placed on a flat stone bed. The wooden press continued in use for three centuries and a half. In the year 1800 Lord Stanhope introduced the first distinct improvement. The wooden screw was abandoned in favour of a system of levers, and the size of the press was increased. Further, it was built entirely of iron, and consisted of a heavy frame in one piece, screwed to a wooden foundation called the "cross." By a combination of levers the platen was made to descend with increasing force until it reached the type or forme. From this time improvements have been continuous. The Stanhope press gave way to the Columbian and Albion presses. The essential parts of the Columbian are stronger than those of the Stanhope, and the recovery of the platen is self-acting. The Albion press is typical of the hand presses now in use. It is lighter and stronger, and more compact than the earlier makes. The process of printing on hand presses is very simple. The forme is laid on the iron bed and fastened to the flanges. The surface of the type is inked by means of a roller. Attached by joints to the end of the press bed is a tympan, consisting of a thin iron frame, over which is stretched a skin of parchment. This is backed up by another thin frame, also covered with parchment, which fits into the tympan frame by means of hooks. Between the two parchments is placed a number of sheets of paper, so that the whole forms a pad into which are also placed the extra sheets prepared in "making ready" (*q.v.*) Each sheet of paper to be printed is placed on the surface of the tympan and lowered on to the forme of type which has already been inked. The bed is then passed under the platen of the press, and the impression made by drawing over a bar actuating certain levers and causing the platen to descend. The frisket—an iron frame over which a sheet of paper is pasted—is sometimes hinged to the top of the tympan. The paper on the frisket is cut away in places where the type is to be printed, and, being laid over the white sheet, falls upon the forme and preserves the margins clean. Originally the formes of type were inked by balls made of cotton wool covered with skins or pelts. With these the face of the type was beaten until a sufficient quantity of ink was distributed. They were superseded by "rollers," which are composed of a mixture of glue and treacle, and these, in improved form, are now in general use.


GUTENBERG'S PRESS.


COLUMBIAN PRESS.

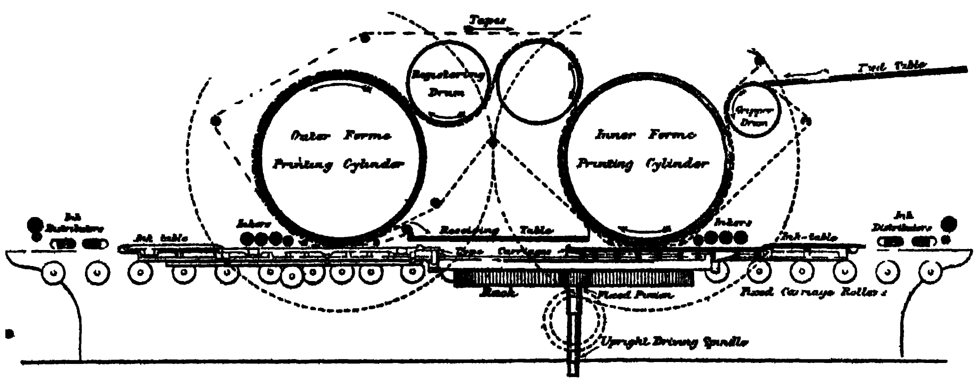

ALBION PRESS.

The term machine, as applied to printing, may be said to have been first used in connection with a mechanism invented by Nicholson, of London, in 1790, worked by steam, and improved by Kœnig about 1807. In this the principle of impression by platen was discarded, and a revolving iron cylinder used to force the paper on to the forme. This machine attracted the attention of Mr. John Walter, revolves in sympathy with the reciprocating motion of the bed. The sheet of paper is presented from a feed board to the edge of the cylinder, which is fitted with a bar running the whole length. Grippers are fixed upon the bar at intervals. The grippers secure the sheet until the cylinder has revolved over the surface of the type, when it is released and carried by tapes or flyers on to the



English Wharfedale Machine.

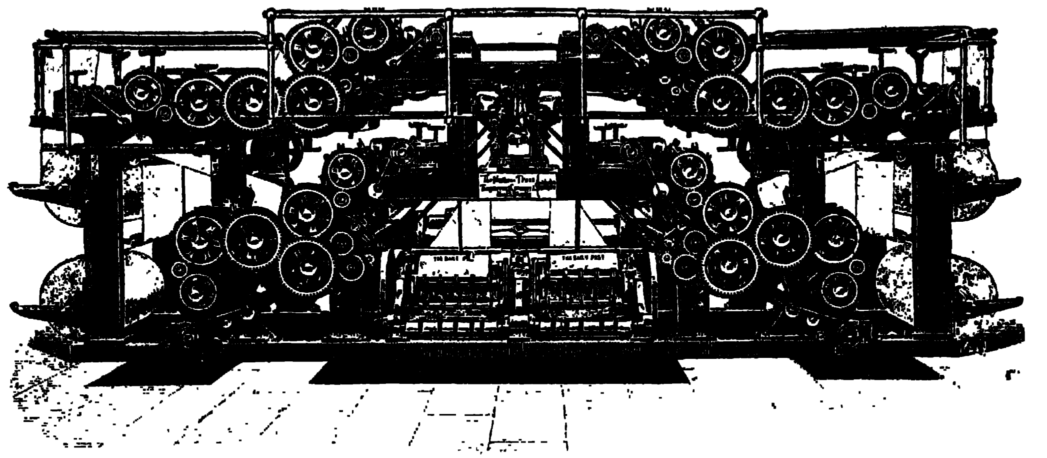
of *The Times*, who ordered one of the same principle to print that newspaper. The machine had two cylinders, was driven by steam, and made about 1,800 impressions in an hour. This cylindrical machine is the basis of all modern advances. Improvements in inking arrangements were made, and the number of cylinders increased until 9,600 delivery board, being printed on one side of the paper only. During the reciprocating movement of the bed the forme is inked by rollers running in forks fixed to the side frames. The ink is contained in a "duct" fixed at the end of the frame of the machine. This duct is in immediate contact with a distributing drum, from which a supply of ink is



Perfecting Machine.

impressions per hour were produced. Of the *Single Cylinder* machine the English Wharfedale best serves as a type of the whole. This machine has two side frames and four cross frames with longitudinal stays. These carry a flat bed or "coffin," upon which the forme travels backwards and forwards. The cylinder is supported on brackets fixed to each of the side frames in the centre, and conveyed by the "vibrator," or roller with a vibrating motion, to a flat iron slab at the end of the reciprocating bed, on which it is evenly distributed by the "wavers." The ink is then taken from the slab by the "inkers" and deposited on the forme. Many improvements in details have been introduced of late years, including the gearing of rollers, by which means their revolutions are

controlled; automatic feeding and "taking off" attachments; special bed and cylinder movements, etc.; but the principle of the machine is not materially altered. Many of the changes made are of American origin, and have resulted from the demand for high class illustrated works and the introduction of the photographic process block, which require extreme rigidity in the construction of the machine, absolute sympathy in all movements, and strict control of ink supply. The actual process of printing is not an involved one. After "making ready," the machine works automatically, and prints the sheets as fed by the "layer on," the "minder" giving attention to the regular flow of ink, etc. The *Platen* machine is a type of vertical bed machine, and may be worked by treadle or steam power. The *Cropper*, or "*Minerva*," was the first to be made, and the general design of this machine is retained in all the newer productions. It consists of two side frames held together by iron stretchers, and to these frames all the working parts are connected. The type is locked up in special chases, and placed on the vertical bed in the back part, the inking arrangements being placed behind and above it. The front part consists of a platen, lying when idle almost flat, and on which the paper is laid to marks or gauges. When the flywheel revolves the platen is pulled forward into a vertical position by two strong arms, one on either side of the machine, and an impression is taken. As the platen returns to its original position, the operator removes the printed sheet and replaces it with a plain one. At the same time the rollers pass over the face of the type, inking it in readiness for the next impression. A large kind of single platen machine called the "*Scandinavian*" is used. Its original purpose was to supersede the hand press. There is also a *Double Platen* variety; but both are being discarded in favour of cylinder machines. *Perfecting Machines* are composed of duplicate mechanisms of the important features of single cylinder machines, with special attachments for reversing the sheet in order that both sides may be printed before it is released. The cylinders of the "Web," "drop bar," and "gripper" varieties are usually larger than is the case with single machines, and in order to avoid the "set off" occasioned by one side of the paper being printed quickly after the other, endless strips of oiled paper pass continually between the impression cylinder and the printed sheet. Of this type of machine there are many varieties, and their purpose is to effect more rapid production. Other Perfecting machines having smaller cylinders are built, and as they possess some of the special advantages of the single machine, are capable of printing work of a much higher character. In *Rotary* machines the printing surfaces as well as the impressing surfaces are cylindrical, and for this reason special stereotype or electrotype plates are now made and curved to conform with the cylinder. The machines vary somewhat in principle: in at least one case the cylinders are arranged in semicircular form, in others on a horizontal plan; the more modern idea is to arrange them vertically. The rotary style of machine dates from 1848, when Applegarth built a machine for printing the *Times*. The type was arranged on a vertical central cylinder, around which were placed eight other vertical cylinders, to each of which there was a feeder, which fed single sheets down a sloping cylinder, to be carried by tapes towards the printing cylinder. When the impression was taken the sheet was carried back horizontally by tapes until it arrived at another table, when, being released by the grippers, the "taker off" disengaged it. The product of the machine was nearly 10,000 copies per hour. Another machine giving nearly 20,000 copies per hour on one side of the paper only was invented by Colonel Hoe, of New York, and used for printing *Lloyd's Newspaper* about 1857. This machine also printed single sheets from movable types. In 1868 Mr. John Walter perfected a machine to print on both sides of the paper from a continuous roll. Further improvements continued to be made, and machines are now capable of printing simultaneously plates of different character in several colours of ink on paper of varying sizes. Being fitted also with folding, pasting, and wire stitching attachments, it is possible to produce complete magazines at the rate of 24,000 per hour. The earlier types of rotary machines were used exclusively for printing newspapers, but it is now possible to produce by



English Rotary Machine.

the more modern variety illustrated work of a fairly high character. A recent type of newspaper machine—Hoe's Octuple—measures 35 ft. in length by 10 ft. in width and 15 ft. high. It has eleven pairs of printing cylinders, forty ink distributing cylinders, 100 composition rollers, twenty-two ink fountains, and 850 gear wheels. In all it is composed of about 50,000 separate pieces. *See also* PHOTO-ENGRAVING, TYPEFOUNDING, TYPES, *and* TYPE SETTING MACHINES.—R. J. E.

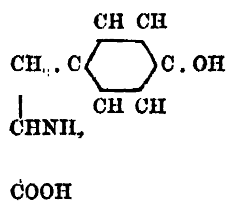
Tyre (*Eng.*) In engineering, etc., a tyre is usually a ring or hoop of iron or steel, encircling the wheel of a vehicle. It may be fixed on by bolts, rivets, etc., by shrinking (*q.v.*) *See* RAILWAY WHEELS.

Tyres, Rubber. The shocks imparted to a vehicle by the irregularities of the road over which it passes may be classified under two main heads: (*a*) The severe shocks, which occur at considerable intervals. (*b*) The minor shocks, which are practically perpetual. To absorb the first class, carefully tempered springs are used on all pleasure and on most commercial vehicles; while the second class is combated by encircling the wheels with rubber tyres. The bicycle has been mainly responsible for the introduction of the rubber tyre, the object being to prevent vibration. The early "boneshaker," iron-rimmed, carried a long and very elastic spring on which the saddle rested. In the 'seventies the SOLID RUBBER TYRE appeared, and did duty on the high bicycle and the earlier patterns of safety cycles. This gave way to the CUSHION TYRE, of tubular section, and was in turn succeeded by the pneumatic air-cushion tyre, now, in its perfected form, generally used. The first PNEUMATIC TYRE was patented in 1846 by a Scotchman named Thompson, and was intended for a horsed vehicle. It had an outer covering of leather bolted to the wooden felloe of the wheel. As there were no light vehicles on which to test and perfect this invention, Thompson's idea proved commercially unsuccessful, and was soon forgotten. Mr. J. B. Dunlop, a veterinary surgeon of Belfast, claims the distinction of first fitting a pneumatic tyre to a cycle wheel. It consisted of an inner tube of sheet rubber, encased in a canvas cover, outside which was solutioned a stout rubber strip. He patented his invention in 1888, and fitted it to racing machines with much success. The "mummy" tyre was attached to the rim by a strip of thin canvas, slit at intervals to pass round the spokes, and made to adhere to the outer cover by rubber solution smeared along its edges. The mending of a puncture in a "mummy" proved so laborious and uncertain that the pneumatic tyre would never have become popular in that form. Various devices—flaps in the tyre itself, manholes in the rim through which the tube might be pulled for repair—were tried, without success. In 1890 two types of DETACHABLE PNEUMATICS appeared: (*a*) the "wired on," patented by Mr. Chas. Kemp Welch; (*b*) The beaded-edge tyre of Mr. W. E. Bartlett. The WELCH COVER depends for its efficiency on the shape of the rim, which is U-shaped. The wired edges of the cover form circles somewhat smaller than the edges of the rim, and can be detached only if one side be pressed well down into the centre of the rim, so as to give the other side a requisite amount of slack. The beaded-edge type is held on by the pressure of inflation, its thickened edges engaging with the turned over edges of the rim. These two patents have been modified since, but not superseded. The CLINCHER and PALMER TYRES are covered by the Bartlett patent, which was purchased by the Dunlop Pneumatic Tyre Company, along with the WOODS VALVE and WESTWOOD RIM patents, before the flotation of that company in 1896. In the first tyres the valve was merely an elastic indiarubber tube closed by a wooden plug. The valves which have replaced it are, like the covers now used, of two main types: (*a*) The metal valve, made airtight by the careful grinding of the valve on its seat. (*b*) The Woods valve, a metal nozzle closed at the inner end and pierced at one side to permit the passage of air. A short length of tube rubber covers this hole, and is pinched at its outer end against and between the nozzle and a seating on the cylindrical body communicating with the inner tube of the tyre, so as to form a simple non-return. The FLEUSS TYRE possesses no inner tube, but the edges of the cover overlap and fit together closely enough to retain the air. The pneumatic tyre, being extremely elastic, minimises the vertical shocks caused by encountering undulations, irregularities, or obstacles on the road's surface. Slight shocks are practically "killed" before they can reach the springs supporting a saddle or vehicle. It thus obviates the loss of power caused by a heavy body being thrust repeatedly in a direction other than that in which alone it should travel. A second advantage is the ability of an air cushion of this type to recover its original shape so rapidly after distortion that it may be said to give a backward kick to an obstacle, which practically compensates for the obstruction to movement caused by its compression. Solid rubber, of a section equal to that of a pneumatic tyre, has much less elasticity and a much slower rate of recovery, and therefore is much less efficient in the foregoing respects.

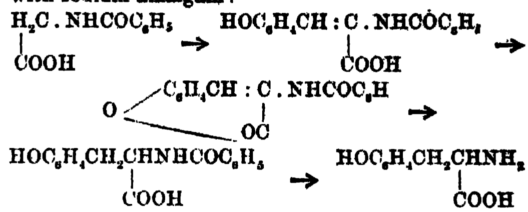
RUBBER TYRES FOR MOTOR VEHICLES.—Motor cars are usually pneumatic shod, in order to be able to move at high speeds without excessive vibration and wear and tear in the working parts. Commercial vehicles and delivery vans employ solid rubber tyres. PNEUMATIC MOTOR TYRES are generally constructed on the beaded-edge principle; but owing to the great strain, especially on the tyres of the driving wheels, they do not depend entirely on the pressure of inflation to keep them tight against the rim. Four or more "security winged bolts," passing at intervals through the rim, are furnished with V-shaped plates, which press on the inside of the cover when their screws are tightened up. These not only make it difficult for the cover to blow off, but also prevent it from "creeping" and tearing out the valve. The Sirdar Tyre Company has produced a tube of a nature which minimises the danger of nipping when it is placed in its cover. The tube is vulcanised in a U-section, so that when deflated, one half springs up into the crown of the other half. When inflated, it assumes a circular shape; but, being rather larger in section than the inside of the cover, the rubber is under compression, and therefore less vulnerable to punctures than a tube which is extended during inflation. Among wired-on motor pneumatic tyres, the PETER UNION may be noticed. The flange on one side of the rim is detachable. It is of circular shape, and split at a point to allow it to pass over the rim when an adjusting screw, working in left and right handed threads in blocks on its free ends, has been turned sufficiently. When the flange is placed in position and the screw has been tightened up, the tyre cannot possibly leave the rim. Heavy car pneumatic tyres are often inflated to a pressure of 120 lb. to the square inch, which approximates the working pressure of some locomotive boilers. Light

car tyres are pumped to 75 lb. to the square inch, and voiturettes to 50 lb. In construction they differ little from the corresponding types of cycle tyres, except that the treads are made disproportionately thick to withstand the very severe work they must do. The replacement of tyres may cost anything up to £50 a set of four. A fast and heavy tourist car is said to wear out its tyres at the rate of sixpence a mile. A violent application of the brakes may cause several pounds' worth of damage by grinding a "flat" on the tyres. SOLID RUBBER TYRES have several advantages. They are more reliable and wear longer than pneumatics, do not raise so much dust, and seemingly are not so prone to sideslip. A good set of "solids" have done duty for 10,000 miles on a heavy vehicle before being worn out. Solids are not, of course, as comfortable to travel on as pneumatics. To obtain a maximum of resiliency, without having recourse to compressed air, the DOUBLE ARCH TYRE has been introduced. It consists of two parts, the outer portion being of special high quality wear-resisting rubber, having a central arch, in which is fixed a sort of small inner tyre of a softer and more elastic nature. The popular method of attaching a solid tyre to its rim is the beaded edge, gripped by removable flanges. Some makers, however, use endless wires embedded in the rubber. For very heavy vehicles, such as motor omnibuses, two, and even three, solid tyres are mounted side by side on a single rim. This method is calculated to give greater freedom from sideslip and a greater amount of resiliency than would be possible with a single tyre of larger section. Many anti-skid and anti-wear devices have been tried for pneumatic tyres. They generally take the form of leather bands, covered with steel studs, and are vulcanised to the outside of the cover. The Parsons anti-skid—a series of short chains crossing the tyre in zigzag fashion, and attached to a wide circle on each side—have proved successful. It may be said of all these devices that while fulfilling their office in a greater or lesser degree, they tend to "slow" the tyre.—A. W.

Tyrosine (*Chem.*)



(Parahydroxyphenol-α-aminopropionic acid). Forms delicate white needles; melts at 235°; very sparingly soluble in cold water (1 in about 2000), but more soluble in boiling water; very slightly soluble in alcohol, insoluble in ether; dissolves in acids or alkalis, forming salts with both; it contains an asymmetric carbon atom, so that naturally occurring tyrosine is active (lævo-rotatory). On heating it loses carbon dioxide and forms parahydroxyphenylethylamine, $H_2N.CH_2CH_2.C_6H_4OH$: treated in water with putrefying pancreas it gives hydroparacumaric acid, $HOOC.CH_2.CH_2C_6H_4OH$: with Millon's reagent (*q.v.*) it gives a red colour: boiled with a dilute formaldehyde to which concentrated sulphuric acid has been added it gives a green colour. It is a product of the hydrolysis of many proteids, *e.g.* casein, keratine, fibroin of silk. It occurs in urine in certain liver diseases, and in phosphorus poisoning: it has been found in plants. Tyrosine can be prepared by boiling white silk (free from gum) with dilute sulphuric acid (100 grs. silk: 200 cc. H_2SO_4: 1000 cc. water) for twelve hours, exactly neutralising with barium hydroxide solution, filtering, extracting the barium sulphate with water, and evaporating the filtrate and extracts to crystallisation. The crude tyrosine is extracted with glacial acetic acid, and the residue dissolved in hot water and boiled with animal charcoal—the filtrate deposits tyrosine. Tyrosine has been synthesised by condensing parahydroxybenzaldehyde with hippuric acid by means of sodium acetate and acetic anhydride: the resulting anhydride of parahydroxy-α-benzoylaminocinnamic acid yields racemic benzoyl tyrosine on reduction with sodium amalgam:



The racemic benzoyl compound can be resolved by brucine (l-form is the less soluble), and on hydrolysis it yields l-tyrosine.

U (*Chem.*) The symbol for URANIUM (*q.v.*)

U Leather (*Eng.*) A leather collar whose section is of the form of the letter U. *See* HYDRAULIC PRESS.

Ulexite (*Min.*) A hydrous calcium sodium borate: $NaCaB_5O_9.8H_2O$, containing 45·6 per cent. of boracic acid. It occurs in opaque white masses, often with Gypsum and Alum. From Iquique, Nova Scotia, California, etc.

Ultimate Strength (*Eng.*) The ultimate strength is the total load which is necessary to break a structure or a given piece of material.

Ultra-Basic Rocks (*Geol.*) Eruptive or igneous rocks, containing less than 45 per cent. of silica. The most characteristic mineral is Olivine: on this account they are often termed PERIDOTITES, from Peridot (*q.v.*)

Ultramarine (*Chem.*) The blue colouring matter of lapis lazuli. On account of its beautiful blue colour it is much valued as a pigment. Formerly it was obtained by grinding the costly lapis lazuli, but now it is prepared artificially on a very large scale. It contains the elements Al, Na, Si, S, and O; but owing to the variation in composition of the ultramarine made by different people, and even by the same people, its formula cannot be regarded as settled. There are ultramarines of several different colours—blue, blue-violet, green, red, and white. As ultramarines of the same colour vary somewhat in composition, it must be said that if, say, blue ultramarine is a definite compound, it has not yet been prepared in a state of purity. An analysis of one of the best blues (Hoffmann) gave Na 17·14, Al 16·25, Si 18·33, S 8·42, and O 39·86 per cent. From this and a large number of other analyses Heumann deduces the formula $Na_6Al_4Si_4S_2O_{16}$ for pure blue ultramarine. The violet-blue ultramarines are richer in silica. White ultramarine is obtained when the roasting of the charge (*see* below) is carried out in absence of air. When the white ultramarine is heated in oxygen

it passes into blue ultramarine, and when the blue variety is heated with sodium carbonate and carbon it passes into the white. Green ultramarine is believed to be a transitional form between the white and blue. Red ultramarine is formed in the preparation of the blue when the charge has been strongly heated and much exposed to air. Besides ultramarines containing sodium, others containing silver, potassium, or lithium, in place of sodium, have been prepared. Ultramarines containing selenium (brown and purple-red) and tellurium (yellow and green), in place of sulphur, have also been prepared. The various blue ultramarines are most used, and next to them the green. In the preparation kaolin, sodium carbonate, sodium sulphate, charcoal (with or without resin), and for silica rich products some form of silica, are used. The materials must be pure, finely divided, and intimately mixed. Their proportions are decided on from the nature of the product required, the experience of the makers, and the method of roasting. If green as well as blue products are required, the charge is roasted in crucible-shaped vessels in ovens, and when the roasting is completed the charge is ground with water and washed. This product is green and ready for use; but if blue is required, it is now heated with sulphur with access of air, and at a lower temperature than before. A part of the sodium is thus removed as sodium sulphate, which dissolves in the washing water. When blue only is required, the operation can be completed in one stage, the charge being protected from air after the roasting is finished till it has cooled down. The product in any case is well washed to remove sodium sulphate, then ground and run into settling tanks, the finest divided settling slowest. Finally the various products are dried. Ultramarine is unchanged by heating, except at a very high temperature, when it becomes white; and acids liberate sulphur dioxide from the white product. Alkalis do not change it, except at a high temperature; but acids easily act on it—*e.g.* hydrochloric acid liberates sulphuretted hydrogen, converts the sodium into chloride which dissolves, a part of the aluminium into chloride which dissolves, a part of the silica into silicic acid which also dissolves, while some sulphur, silica, and alumina remain undissolved. A warm solution of alum easily decomposes the silica-poor ultramarines; but only acts slowly on the silica-rich varieties. Oxidising agents at a high temperature readily decompose all ultramarines. Besides being used as a pigment, ultramarine is much used in making laundry blue, and in "correcting" the yellow colour of paper, linen, sugar, etc., in making blue printing ink, writing paper, mottled soap, etc.

Ultramarine (*Paint.*) A blue pigment largely used by house painters, printers and others, and made by heating together a mixture of china clay, soda ash, sulphur, sodium sulphide, sodium sulphate, and resin. The manufacture of ultramarine is in the hands of a very few firms, and paint makers invariably purchase it ready made. It varies largely in composition according to the purpose for which it is to be used. It works well in distemper and in oil, but must not be mixed with white lead. Originally ultramarine was made for artists' use from lapis lazuli, but this is now almost wholly discontinued, the cost being very great.

Ultra-Neptunian Planets (*Astron.*) Possible planets that may revolve round the sun at a greater distance than Neptune.

Ultra-Violet Rays (*Phys.*) Rays whose wave length is too short to excite the sensation of vision. They accompany in greater or less degree the visible radiation from most sources of light, and constitute an invisible prolongation of the spectrum beyond the violet. They may be easily detected by photographic means or by allowing the rays to fall upon a screen such as is used in Röntgen Ray experiments, when fluoresence is produced.

Umbelliferæ (*Botany*). A natural order of Dicotyledons containing many plants of economic value. The Carrot, Parsnip, Celery, are well known vegetables, while Caraway, Coriander, Fennel, Anise, etc., enter into pharmaceutical preparations.

Umber (*Min.*) An earthy variety of Limonite, used as a pigment. It is found in the Isle of Man, in the Forest of Dean, Saddleback, in Cyprus, etc.

—— (*Paint.*) A natural earth of a brown colour which is sold as "raw umber" and "burnt umber," the latter being subjected to heat which intensifies the colour. Umber is largely used by grainers for obtaining rich, deep effects, and by house painters to assist in producing many dark, rich colours and also for lessening the brilliancy of mixed colours in general. They are comparatively cheap, quite permanent, and may be safely used when ground either in water, turpentine, or oil.

Umbo (*Arm.*) The boss or knob, sometimes terminating in a spike, in certain forms of shield, especially the small round shield or buckler. The term was sometimes applied to the shield itself.

Umbra. The darkest central portion of the shadow cast by a body. It is surrounded by the penumbra (*q.v.*)

Umbrian School of Painting. *See* PAINTING, SCHOOLS OF

Una Corda (*Music*). A sign indicating that the left pedal of the pianoforte is to be used. By this pedal the action is moved slightly to the right, causing the hammer to strike only two of the three strings of each note. Formerly only one string (*una corda*) was struck. Some makers cause a strip of felt to drop between the hammers and the strings when the left pedal is depressed. This gives to the notes a muffled sound, an effect very different from that intended by *una corda*, which produces a tone of delicate and special quality. The direction *tre corde* (three strings), or *tutte le corde* (all the strings), indicates that the left pedal is to be discontinued. Beethoven, in the pianoforte Sonata in B♭, Op. 106, has the following direction after *una corda: poco a poco due ed allora tutte le corde* (gradually two and then all the strings), indicating the gradual release of the left pedal (*see also* PIANOFORTE, *p.* 429). On stringed instruments *a una corda* shows that the whole passage is to be played on one of the strings only.

Unbuilding (*Elect. Eng.*) The demagnetisation of the field magnets of a dynamo or motor.

Uncaria Gambier. A climbing plant (*Rubiaceæ*) from Polynesia and Singapore. The young shoots and leaves yield an extract, CATECHU (*q.v.*)

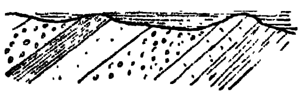
Uncial. The term is used to denote the style of writing found in early manuscripts (4th—9th centuries) before the introduction of the "new" cursive

hand. Uncial characters resemble modern capitals, but are rounder in form:

Uncial: ΚΑΙΕΓΕΝΕΤΟΕΝΤΩ
Capitals: ΚΑΙΕΓΕΝΕΤΟΕΝΤΩ

In Greek palæography the distinction between the capital and the uncial is insignificant, except that the latter is more rounded in outline, but in Latin MSS. the difference is much more marked. The uncial continued in use until the 9th century, the style of the transition period being known as the SEMIUNCIAL. Uncials were employed in the books of the Church until a much later period. *See* MAJUSCULE and MINUSCULE (Appendix)

Unconformity (*Geol.*) The relationship of a set of newer rocks to an older set of rocks which have been tilted, or otherwise disturbed, and have undergone denudation before the newer ones were deposited. The new rocks thus lie across the edges of the older ones, as in the diagram. *See also* CONFORMABLE SUCCESSION.



UNCONFORMITY.

Unda Maris (*Music*). An organ stop which produces a tone of a waving character similar to the Voix Céleste. The term means sea wave.

Undée *or* **Wavy** (*Her.*) Wavy or undulating: one of the partition lines. *See under* HERALDRY.

Undercut (*Eng., etc.*) This term is applied to parts of an object below some other overhanging portions; to re-entrant angles (*q.v.*), etc. Also applied specifically to (1) parts of patterns whose diameter increases towards the bottom, and which therefore cannot be withdrawn from the mould in the ordinary way; (2) various operations that are carried out from the underside, *e.g.* in mining, as well as to machines arranged to operate from the underside; (3) a carving or moulding that has the parts in relief partially cut away or bevelled on the underside.

Under Glaze Decorations (*Pot.*) Decorations which are placed upon the bisque ware, to be afterwards glazed and burnt in the glost oven. *See* BISQUE.

Underground Conductor (*Elect Eng.*) A name applied either to (1) an insulated wire which may be cased with damp proof material and laid directly in the earth, or may be carried in a conduit or pipe; or (2) to the bare conductor of an electric tramway on the slotted conduit system. *See* ELECTRIC TRACTION.

Underground Railways (*Civil Eng.*) Underground railways are conveniently divided into two types—the shallow tunnel with numerous open cuttings (*e.g.* the Metropolitan and District Railways) and the deep level or Tube Railways (*e.g.* Central London). The former is largely constructed on the "cut and cover" plan, open cuts being made and afterwards arched over, actual tunnelling being avoided as much as possible; while the latter are continuous tunnels, with linings of tubular form, built up of segments of cast iron. Separate tunnels are generally used for the up and down lines, each tunnel having a diameter of 10 to 12 ft. The stations are contained in short lengths of tunnel of larger diameter, the linings being of brick. The approaches are formed by tubular shafts containing electric or hydraulic lifts, with auxiliary staircases in some cases. The depth at which these lines are constructed is sufficient to prevent interference with sewers and pipes; but the vibration produced is very distinctly felt in buildings in the vicinity. The City and South London line cost about £220,000 per mile.

Underground Temperature (*Meteorol.*) For the measurement of the penetrative powers of the solar heat rays into the earth's surface, thermometers of various construction are placed at different depths and read regularly.

Underlay (*Print.*) Resembling an overlay (*q.v.*) in character, but placed beneath instead of above the block to be printed.

Underpin (*Build.*) To support or renew the foundation of a wall, etc.

Underpick (*Weaving*). A picking motion in which the picking arm is under the shuttle box. A very common motion in quick running looms. *See* OVERPICK *and* PICKING.

Under Poled (*Met.*) *See* COPPER *and* POLING.

Undershot Wheel (*Eng.*) A water wheel in which the water acts only on those floats that are near the bottom of the wheel. It therefore depends for its supply of energy on the velocity (*i.e.* the Kinetic Energy) of the water, which may be flowing along a perfectly horizontal channel while passing under the wheel.

Undertype Magnet (*Elect. Eng.*) The field magnet of a two-pole dynamo or motor which has its poles (and therefore the armature) next to the base plate.

Undulations (*Phys.*) An expression generally used as equivalent to Waves. *See* WAVE MOTION.

Undulatory Discharge (*Elect.*) An OSCILLATORY DISCHARGE (*q.v.*)

Undulatory Theory of Light. The WAVE THEORY (*q.v.*)

Undulatory Winding (*Elect. Eng.*) *See* WAVE WINDING.

Unequal Temperament (*Music*). The old system of tuning which gave certain keys correctly in tune, whilst leaving others unusable.

Unessential Notes (*Music*). Passing notes and auxiliary notes (*q.v.*)

Unguentarium (*Archæol.*) A vase used for holding oil, etc., for anointing the body.

Unhairing (*Leather Manufac.*) The process of removing hair from hides and skin, previous to tanning. *See* SWEATING *and* LEATHER MANUFACTURE, *p.* 349.

Uniaxal Crystals (*Phys., Min.*) A crystal having one optic axis. *Cf.* BIAXAL CRYSTAL *and* DOUBLE REFRACTION.

Unicorn (*Her.*) A fabulous animal occurring sometimes as a charge in heraldry. The body is that of a horse with the legs of a buck and the tail of a lion, a single straight horn growing out of the forehead. The unicorn is one of the supporters of the Royal Arms of Great Britain.

Unidirectional Current (*Elect.*) A current flowing in one direction only as opposed to an alternating current.

Union (*Build.*, *Eng.*, *etc.*) A device for connecting the ends of two pieces of pipe. In the simplest form it consists of a threaded tubular socket, into which the ends of the pipes are screwed.

—— (*Textile Manufac.*) A fabric composed of two or more materials, such as cotton warp and mungo weft, worsted warp and woollen weft.

Union Blanket. *See* BLANKET.

Union Wrench (*Eng.*, *etc.*) A lever, one end of which is curved so as to fit against a union (*q.v.*), a pin in the curved end fitting into a hole in the union to enable it to be turned by the lever.

Unison (*Music*). Two or more notes of the same pitch, *i.e.* having the same number of vibrations per second, sounded together (*see* INTERVALS). When vocal or instrumental passages are performed in octaves they are sometimes, though incorrectly, said to be in unison.

Unit. A selected quantity, whose amount is fixed and invariable, used as a standard of comparison in stating or determining the amounts or values of other quantities of the same nature. The numerical value of any quantity is the number of times which it contains the chosen unit, or in other words the ratio of the magnitude of the quantity to the magnitude of the unit. *See also* UNITS, FUNDAMENTAL *and* DERIVED.

Unit Charge of Electricity (*Elect.*) A charge of electricity such that if placed at one centimetre in air from an equal quantity, it exerts on it a force of one dyne (all other electrical forces being absent, and the two charges being supposed to be concentrated at mathematical points).

Unit Jar (*Elect.*) A small Leyden jar used to measure roughly the electrical capacity of a larger jar or condenser.

Unit of Heat. *See* CALORIE.

Unit Pole (*Magnetism*). A pole such that if placed at unit distance in air (or other material whose magnetic permeability is unity) from an equal pole, it exerts on it a force of one dyne (all other magnetic forces being absent, and the two poles being assumed to be mathematical points).

Units, Absolute System of (*Phys.*, *etc.*) A system based upon certain fundamental units (*e.g.* the units of mass, space, and time) from which all others are derived by means of certain definite physical relations.

Units, Dimensions of (*Phys.*) *See* UNITS, DERIVED.

Units, Fundamental and Derived. The fundamental units generally chosen are those of LENGTH, MASS, and TIME. In most scientific work the centimetre, gram, and second are used, though the foot, pound, and second are also used (*see* WEIGHTS AND MEASURES). From these three fundamental units others, termed DERIVED UNITS, are obtained. Thus the unit of area depends upon the square of the unit of length, but not in any way upon the units of mass and time. This is expressed in scientific language by saying that the DIMENSIONS of this unit are 2, 0, 0, with respect to length, mass, and time. This relation is shown by a DIMENSIONAL EQUATION thus:

$$A = L^2M^0T^0.$$

The unit of volume has similarly dimensions 3, 0, 0 with reference to the three fundamental units.

The chief units used in mechanics and their dimensional equations are as follows;

Velocity	$V = LT^{-1}$
Acceleration	$A = LT^{-2}$
Force	$F = LMT^{-2}$
Work	$W = L^2MT^{-2}$

See also DYNE, ELASTICITY, ERG, POUNDAL, FOOT-POUND, HORSE POWER, *etc.* The units used in heat require a fresh unit, that of temperature, whose dimensions with respect to length, mass, and time are unknown, and which is therefore represented by a separate symbol, θ. It has been termed a SECONDARY FUNDAMENTAL UNIT. The ordinary scientific unit of heat, the CALORIE (*q.v.*), has dimensions

$$Q = M\theta.$$

See also ABSOLUTE TEMPERATURE, CONDUCTIVITY, DIFFUSIVITY, ELASTICITY, JOULE, JOULE'S EQUIVALENT, *etc.* For units used in Light, see PENTANE STANDARD, PHOTOMETRY, STANDARD CANDLE, *etc.*

The electrical and magnetic units are derived from the mechanical units, but also require the introduction of the permeability, μ (*q.v.*), and specific inductive capacity, K (*q.v.*), of the media in which the electrical and magnetic phenomena are taking place in order to be complete. Two systems of units are in use. The first is the ELECTROSTATIC SYSTEM OF UNITS, in which unit charge is defined as that which exerts unit force on an equal quantity placed at unit distance from it in air. The dimensions of this unit are given in the equation—

$$Q = L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}K^{\frac{1}{2}}.$$

From the unit charge the units of force, potential, capacity, etc., are obtained.

In the second or ELECTROMAGNETIC SYSTEM the dimensions of the unit of quantity are expressed by the equation—

$$Q = L^{\frac{1}{2}}M^{\frac{1}{2}}\mu^{-\frac{1}{2}}.$$

The unit current is that in which unit quantity flows across a given cross section of the conductor in unit time; the dimensions are given by

$$C = L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}\mu^{-\frac{1}{2}}.$$

This unit is otherwise defined in practice as follows: If unit length (1 c.m.) of the circuit carrying the unit current be bent into an arc of unit radius it will exert unit force (1 dyne) upon a unit magnetic pole placed at the centre of the arc. The AMPERE (*q.v.*) is one-tenth of this unit. UNIT DIFFERENCE OF POTENTIAL exists between two points if unit work (1 erg) be required to be done in order to transfer a unit quantity from one of the points to the other. The volt is 100,000,000 or 10^8 times this unit.

UNIT RESISTANCE is the resistance of a conductor in which unit current is produced by unit difference of potential between the ends. The OHM is 1,000,000,000 or 10^9 times this unit. *See also* AMPERE, CAPACITY CONDUCTANCE, COULOMB, JOULE, MAGNET, MHO, OHM, POTENTIAL DIFFERENCE, VOLT, WATT, etc.

Universal Chuck (*Eng.*) A chuck with self centering jaws. *See* SELF CENTERING CHUCK.

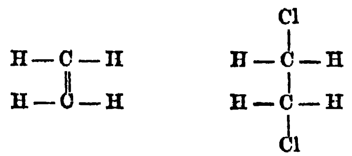
Universal Joint (*Build.*) A joint used in gas-fitting to connect two pipes in such a manner that one of them can be turned in any required direction.

—— —— *or* **Coupling.** *See* HOOKE'S JOINT.

Universal Machine (*Print.*) A small platen machine which may be worked by treadle or by power. *See* TYPOGRAPHY.

Unlock (*Typog.*) To loosen the quoins and furniture of a forme of type for the purpose of making corrections, etc.

Unsaturated Compounds (*Chem.*) A compound A is said to be unsaturated when a compound B can be prepared from it by direct addition of one or more than one atom or group of atoms in such a way that one or more than one atom in B is united to a greater number of atoms or groups of atoms than it was united to in A. Thus carbon monoxide is an unsaturated compound, because a compound carbon dioxide can be formed from it by direct addition of oxygen; and we believe the oxygen to be added in such a manner that, while the carbon atom in carbon monoxide is united to one atom of oxygen, the same atom is united to two atoms of oxygen in carbon dioxide. Again, ethylene is regarded as an unsaturated compound because it unites directly with chlorine to form ethylene chloride in such a way that, while in ethylene each carbon atom is united to two hydrogen atoms and one group CH_2, in ethylene chloride each carbon atom is united to two hydrogen atoms, one chlorine atom, and one group CH_2Cl. This is represented by formulæ as follows:



The double line joining the two carbon atoms in the formula for ethylene is the conventional way of indicating that ethylene is unsaturated, and unsaturated to the extent indicated by its union with two atoms of chlorine—that is to say, ethylene could conceivably add on something other than chlorine, but in such a case the atoms or groups added must be chemically equivalent to the chlorine. Calcium chloride is not ordinarily regarded as an unsaturated compound, in spite of the fact that it can unite with water, ammonia, and alcohol to form compounds, $CaCl_2 . 6H_2O$: $CaCl_2 . 8NH_3$: $CaCl_2 4C_2H_5OH$; for it cannot be shown that the calcium atom is united to any other element than chlorine in these compounds, and similarly for the chlorine. *See* VALENCY *and* WERNER'S THEORY.

Unsized Paper (*Print.*) "Blotting" and other very absorbent papers are manufactured without size. Papers in which only a small portion of the ingredient is used—technically called "soft sized"—are very suitable for printing illustrated or half tone work.

Unsound Food. *See* FOODS.

Unstable Equilibrium (*Phys., etc.*) *See* EQUILIBRIUM, UNSTABLE.

Unstratified Rocks (*Geol.*) A general term applied to Igneous or Eruptive Rocks, which do not occur in regular strata, but in more or less irregular masses, known as DYKES, VEINS, etc.

U Packing (*Eng.*) *See* U LEATHER.

Upcast *or* **Uptake** (*Mining*). A shaft in a mine for the upward passage of air.

Upheaval (*Geol.*) An upward movement of a portion of the Earth's crust; the resulting displacement of the rocks is accompanied by dislocations, faults, and other disturbances of the strata affected.

Upholstery. The business of fitting and "covering" furniture with various materials, *e.g.* springs, stuffing, coverings, trimmings, etc.; also the decoration of an apartment with textile fabrics, *e.g.* curtains, etc.

Upper Board (*Music*). (1) The board in which the feet of organ pipes stand. (2) The top board of the bellows on which the weights are placed. *See* ORGAN, *p.* 439.

Upper Case (*Typog.*) *See* TYPOGRAPHY, *p.* 803.

Upright Grand (*Music*). A grand pianoforte made to occupy a vertical instead of a horizontal position, to save space.

Upsetting (*Eng.*) (1) Shortening or thickening metal either by hammering or by machinery, as in the case of a wheel tyre. *See* JUMPING UP. (2) Spreading the teeth of a saw. *See* SAW SETTING.

Uptake (*Eng., etc.*) A flue leading from a furnace to a chimney.

—— (*Mining*). *See* UPCAST.

Uranic Ochre (*Min.*) A hydrous basic calcium uranium sulphate occurring in association with Pitchblende. It is a yellow powdery mineral. From Cornwall, Bohemia, and Connecticut.

Uraninite (*Min.*) A synonym for Pitchblende (*q.v.*)

Uranite (Copper) (*Min.*) *See* TORBERNITE.

—— **(Lime)** (*Min.*) *See* AUTUNITE.

Uranium (*Chem.*) U. Atomic weight, 238·5. A somewhat rare metal belonging to Series 12, Group VI. of the Periodic System (*q.v.*); it has the highest atomic weight of all the elements. Uranium is a white metal; melting point unknown, but high—in the electric furnace it volatilises more readily than iron. Specific gravity 18·7; in finely divided state it is easily oxidised in air, especially on heating, and it decomposes water slowly at ordinary temperatures, and quicker on heating; it is soluble in dilute hydrochloric and sulphuric acids. When heated to a high temperature (1000°) it readily combines with nitrogen, so that this gas must be excluded from the apparatus in preparing the metal. It reduces solutions of many metallic salts to the metal, *e.g.* Pt, Au, Ag, Hg, Cu, Sn. It occurs principally in pitchblende (*q.v.*), which contains 40 to 90 per cent. of the oxide U_3O_8. The metal is obtained as follows: The vapour of uranium tetrachloride is passed over red-hot sodium chloride to form the compound $2NaCl . UCl_4$, and this may be heated with sodium or melted and electrolysed (50 ampères, 10 volts) with carbon electrodes in an atmosphere of dry hydrogen. Uranium is a radioactive element (*see* RADIO-ACTIVITY and RADIUM). It differs from Thorium (*q.v.*) and Radium in not giving an emanation; α, β, and γ rays are emitted by uranium, but the γ radiation is the feeblest of the three. The metal owes its photographic properties chiefly to the β rays, its ionising action chiefly to the α rays. This can be proved by precipitating a uranyl salt solution with ammonium carbonate (*see* under Uranyl Nitrate), treating the precipitate with excess of ammonium carbonate, and filtering off the slight remaining

precipitate. The product, which is in extremely minute amount, is called UrX, and possesses all the photographic activity of the original uranium, while the uranium solution is photographically inactive, but electrically as active as before. While the activity of UrX decays (half in about twenty-two days), the uranium from which it was separated recovers its activity at the same rate. One gram of uranium emits about 70,000 α particles in a second, corresponding to a development of heat equal to ·3 gram-calories in a year. The β and γ rays contribute an amount of energy equal to about one per cent. of that due to the α rays. COMPOUNDS: Uranium carbide, U_2C_3, is a crystalline, metallic-looking solid; specific gravity 11·3. It is decomposed by water with evolution of a gas which contains about four-fifths of its volume of methane, the other fifth consisting chiefly of hydrogen and very small quantities of ethylene and acetylene, while two-thirds of the carbon of the carbide goes to form a mixture of liquid and solid hydrocarbons, saturated and unsaturated. When heated it burns brightly in oxygen, and for the same reason two pieces when rubbed together emit bright sparks. It is obtained by heating an intimate mixture of pure sugar charcoal and the oxide U_3O_8 in an electric furnace (900 ampères, 50 volts). OXIDES: Uranium dioxide, UO_2 (uranous oxide), is a brown powder; it is pyrophoric if obtained by heating uranyl oxalate out of air, or by reducing a higher oxide in hydrogen at as low a temperature as possible. When obtained by reduction at a high temperature it has a coppery lustre, and is not pyrophoric; strongly heated in oxygen or steam, it gives the oxide U_3O_8. Insoluble in water or hydrochloric acid, but soluble in nitric acid and in sulphuric acid containing only a little water forming, on boiling, uranous sulphate. It is obtained by heating the oxalate out of air, or by reducing the oxide U_3O_8 by heating in hydrogen. URANIUM TRIOXIDE, UO_3: A brick-red powder; loses oxygen on heating, forming the oxide U_3O_8. With acids it forms uranyl salts, with bases it forms uranates. It is obtained by heating the hydrate UO_3H_2O, or uranylammonium carbonate

$$UO_2 . CO_3 2(NH_4)_2CO_3,$$

or uranyl nitrate, at 250° to 300°. URANOSOURANIC OXIDE, U_3O_8 (uranyl uranate, $UO_2 . 2UO_3$, green oxide of uranium): This is the most important oxide of uranium. It is a powder varying in colour from a very dark green to black, but always gives a green streak. Insoluble in water, insoluble in dilute acids; soluble in nitric acid, giving uranyl nitrate; soluble in sulphuric or hydrochloric acids at about 200°, giving a mixture of uranous and uranyl salts. It is reduced to the dioxide when heating with reducing agents, or even on prolonged heating in an indifferent gas (N or CO_2). It is obtained by heating either of the two previous oxides or uranium nitrate in air. This oxide is the form in which uranium is contained in pitchblende; it is used to produce a black glaze on porcelain, and in the preparation of other uranium compounds. It is obtained from pitchblende by the following process: The ore is roasted with sodium carbonate containing a small quantity of sodium nitrate (the ore is sometimes roasted alone first), and the product is extracted with hot water, which extracts sodium salts of uranium (a little), molybdenum, tungsten, and arsenic; the residue is treated with a mixture of pretty strong sulphuric acid and a little nitric acid. The clear liquid is separated from the residue (it is this residue that contains radium, *q.v.*) and treated with excess of sodium carbonate; this solution is boiled to remove the last traces of iron and calcium. The filtered liquid, when cautiously neutralised with sulphuric acid, yields uranium yellow (sodium diuranate); if it is boiled with caustic soda it yields orange-coloured uranium yellow (probably another form of sodium diuranate); or if the liquid is treated with ammonium chloride it yields a precipitate of uncertain composition (an impure ammonium uranate) which yields the oxide U_3O_8 on ignition. URANIC HYDRATE, $MO_3 . H_2O$ or $MO_2(OH)_2$ (also called uranic acid), is a yellow powder, insoluble in water, but reddens moist litmus, and when hot absorbs carbon dioxide; on heating it yields first the trioxide (*q.v.*) and then the oxide U_3O_8. It is obtained by boiling an alcoholic solution of uranyl nitrate till no further oxidation of the alcohol occurs, washing the yellow solid so obtained and drying it in air, then *in vacuo*, or by exposing uranyl oxalate in water to sunlight, and washing and drying as before. URANATES may be regarded as derived from the preceding compound by replacement of water by basic oxides. Normal, di-, and poly- uranates are known ($R_2O . UO_3$, R_2O2UO_3, R_2OnUO_3, where R is a monovalent metal or group). Of the uranates the diuranates are the commonest. SODIUM DIURANATE, $Na_2U_2O_7 6H_2O$, is a light yellow or orange yellow powder obtained by adding insufficient or excess respectively of caustic soda to a uranyl salt solution (*see* Uranosouranic Oxide). It is used as a pigment under the name uranium yellow, and in making the fluorescent uranium glass (greenish fluorescence). CHLORIDES: A trichloride, UCl_3, is said to exist. URANIUM TETRACHLORIDE, UCl_4: Dark green octahedral crystals; volatilises at a red heat, and has a normal vapour density. Fumes in air, is deliquescent, and dissolves in water, forming a green solution; reduces gold and silver salts to the metal, and ferric to ferrous salts. It is obtained by heating a mixture of any of the above oxides with carbon in a stream of dry chlorine. Pentachloride, which is formed simultaneously, is decomposed by heating in an indifferent gas, such as CO_2. URANIUM PENTACHLORIDE, UCl_5, forms dark needles with green lustre or a light reddish-brown powder, according as it is formed by heating the tetrachloride in a slow or a rapid stream of dry chlorine respectively; when heated it decomposes. It is deliquescent, and when thrown into water evolves hydrogen chloride. URANOUS SALTS: Uranous chloride is the tetrachloride mentioned above. URANOUS SULPHATE, $U(SO_4)_2 4H_2O$, forms green crystals; on heating it loses sulphuric acid and forms uranyl sulphate; heated in hydrogen it gives the dioxide. It is formed by dissolving the oxide U_3O_8 in hot dilute sulphuric acid, adding alcohol, and exposing to sunlight, when the uranyl sulphate which is formed, as well as uranous sulphate, is reduced to the latter. It forms double salts with the sulphates of the alkali metals, *e.g.* $U(SO_4)_2K_2SO_4H_2O$. URANYL SALTS: Salts of the formula UO_2X_2, where X is a monovalent acid radical. URANYL CHLORIDE, UO_2Cl_2: A yellow crystalline solid, easily melted; soluble in water, alcohol, ether. It can be obtained by heating the dioxide in chlorine, or by dissolving uranic hydrate in hydrochloric acid and crystallising, when it separates with one molecule of water. URANYL NITRATE, $UO_2(NO_3)_2$, is often, but erroneously, called uranium nitrate. It is a yellow solid with green fluorescence, crystallising in columns or plates, and with $6H_2O$

from water; melts at 60°; loses the water at 118°; on strongly heating it gives the oxide U_3O_8. The salt is soluble in alcohol (*see* under Uranic Hydrate), also soluble in ether. It is phosphorescent. The solutions give an absorption spectrum, as do all uranyl salts. Ammonium carbonate gives a yellow precipitate soluble in excess of the reagent, owing to formation of uranylammonium carbonate, $UO_2CO_3 2(NH_4)_2CO_3$. Uranyl nitrate is made by dissolving any oxide of uranium in nitric acid and crystallising the solution. Uranyl phosphate, UO_2HPO_4, with a variable amount of water, is formed as a precipitate when a soluble uranyl salt is treated with a soluble phosphate; it is a pale yellow solid, very insoluble in water and dilute acetic acid. Its formation is utilised both gravimetrically and volumetrically in the estimation of phosphates. When heated it gives the pyrophosphate $(UO_2)_2P_2O_7$, in which form the precipitate is weighed in gravimetric analysis. Uranyl acetate, $UO_2(C_2H_3O_2)_2$, is made by heating uranyl nitrate till oxygen begins to be evolved, then dissolving the residue in warm, strong acetic acid and crystallising. On boiling its solution strong hydrolysis occurs. It is used in estimating phosphates volumetrically. Uranyl salt solutions give a reddish-brown precipitate with potassium ferrocyanide, and this reaction is so delicate that it is used as an indication of the end reaction in the estimation of phosphates volumetrically.

Uranium (*Min.*) Occurs only in combination in nature. The principal ores are Pitchblende, Autunite, Torbernite, Uranophane, Samarskite, Euxenite, Polycrase, Ånnerödite.

Uranus, Planet (*Astron.*) Distance from sun, 1,781,900,000 miles; diameter 31,900 miles; periodic time, 84 years. Four satellites (if not more), which move in a plane nearly at right angles to the Ecliptic (75°).

Uranyl Compounds (*Chem*) *See* URANIUM.

Urceus (*Archæol.*) A ewer, generally of metal, to hold water for washing. The diminutive is URCEOLUS.

Urea (*Chem.*) $CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2}$ (Carbamide).

White prisms; melts at 132°; very soluble in water; readily soluble in alcohol; insoluble in ether and in chloroform; it is a monacid base forming salts which are all soluble in water, the nitrate and oxalate being the least soluble—the nitrate is less soluble in nitric acid than in water, and therefore its formation is used as a test for urea. It unites with numerous metallic salts—*e.g.* with sodium chloride, forming $CO(NH_2)_2 . NaCl . H_2O$; with palladious chloride, forming $2CO(NH_2)_2 . PdCl_2$, which is very insoluble; with mercuric nitrate (when warmed with a dilute solution of urea), forming the basic compound $2CO(NH_2)_2 . Hg(NO_3)_2 . 3HgO$ (basis of Liebig's method of estimation of urea). When heated a little above its melting point, urea gives off ammonia and forms biuret (*q.v.*) and cyanuric acid:

$$2CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2} = CO\genfrac{<}{}{0pt}{}{NH_2}{NH . CONH_2} + NH_3$$

$$3CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2} = C_3H_3N_3O_3 + 3NH_3.$$

A solution of urea heated to 100° is partially transformed to ammonium cyanate (5 per cent.); but by adding silver nitrate so as to precipitate the cyanate, about 88 per cent. can be transformed; when boiled with alkalis, urea is hydrolysed:

$$CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2} + 2HOK = CO(OK)_2 + 2NH_3$$

A number of bacteria and moulds hydrolyse urea to ammonium carbonate—some of these are widespread, occurring in air, soil, and water; the micrococcus ureæ is one of the commonest. Urea is decomposed, but not quite completely, by alkaline hypobromites, and less readily by alkaline hypochlorites:

$$CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2} + 3NaOBr = 3NaBr + CO_2 + N_2 + 2H_2O$$

The carbon dioxide is completely absorbed if excess of caustic soda is used and the nitrogen alone escapes (basis of clinical estimation). Nitrous acid decomposes urea completely:

$$CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2} + 2HNO_2 = CO_2 + N_2 + 3H_2O$$

In fairly strong solution urea reacts with phenylhydrazine in strong acetic acid solution to form phenylsemicarbazide, a white crystalline solid melting at 170°:

$$CO\genfrac{<}{}{0pt}{}{NH_2}{NH . NHC_6H_5}.$$

Urea yields a nitro-derivative—

$$CO\genfrac{<}{}{0pt}{}{NH . NO_2}{NH_2},$$

which is obtained by adding urea nitrate to concentrated sulphuric acid. It is a white crystalline solid which behaves as a strong acid; nitrourea is used in the preparation of semicarbazide (*q.v.*) Urea occurs in urine; an adult in health excretes about 1·5 litres of urine in 24 hours, and this contains from 21·5 to 34 grams of urea; it also occurs in the blood and perspiration. It can be obtained synthetically by gently heating ammonium carbamate—

$$CO\genfrac{<}{}{0pt}{}{NH_2}{ONH_4} = CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2} + H_2O;$$

also by the action of ammonia on carbonyl chloride:

$$CO\genfrac{<}{}{0pt}{}{Cl}{Cl} + 2NH_3 = CO\genfrac{<}{}{0pt}{}{NH_2}{NH_2} + 2HCl.$$

When a solution of ammonium cyanate is evaporated on the water bath to dryness, it is transformed into urea, $NH_4CNO = CO(NH_2)_2$. In quantity urea may be prepared by heating anhydrous potassium ferrocyanide with potassium carbonate, when a mixture of potassium cyanate and cyanide is obtained; this mixture is then heated with red lead till all cyanide is oxidised to cyanate ($4KCN + Pb_3O_4 = 4KCNO + 3Pb$); the cyanate is now treated with ammonium sulphate solution, filtered from the potassium sulphate that separates, and evaporated to dryness on the water bath; the dry residue is repeatedly extracted with absolute alcohol; excess of alcohol is distilled off, and the rest allowed to stand till the urea crystallises out. To obtain urea from urine, the urine is evaporated to a syrupy consistency on the water bath; when cool, concentrated nitric acid is added—urea nitrate crystallises out. The nitrate is filtered off (through glass-wool), decomposed by warming with barium carbonate and water for several hours, filtered from excess of barium carbonate, and evaporated to dryness on the water bath; the mixture of barium nitrate and urea is separated by extraction with absolute alcohol as before.

Ureides (*Chem.*) Compounds formed by elimination of water between urea and an acid or aldehyde. Parabanic acid (*q.v.*) is a ureide; so are alloxan, alloxantin, uramil, etc.—all mentioned under Uric Acid (*q.v.*)

Ureter (*Zoology*). The urinary duct leading from the kidney to the bladder or to the cloaca.

Urethanes (*Chem.*) The esters of carbamic acid.

$$CO<^{NH_2}_{OH} \qquad CO<^{NH_2}_{OC_2H_5}$$

Carbamic acid (unknown). Ethyl carbamate (urethane).

Ethyl carbamate is a white crystalline solid; melts at 50°; boils at 184°; sublimes below its boiling point; easily soluble in water and in alcohol. It is easily hydrolysed by alkalis:

$$CO<^{NH_2}_{OC_2H_5} + 2HONa = CO<^{ONa}_{ONa} + NH_3 + C_2H_5OH$$

Heated with ammonia, it gives urea. Urethane is obtained by allowing ethyl carbonate (a colourless liquid obtained by the action of ethyl iodide on silver carbonate) to stand in contact with ammonia till it has all gone into solution, then evaporating *in vacuo*. If amines be used in place of ammonia, alkyl urethanes are obtained—*e.g.* with methylamine, methylurethane—

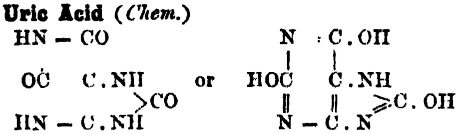
$$CO<^{NHCH_3}_{OC_2H_5}$$

is obtained; it is a colourless liquid. When an ethereal solution of methylurethane is kept cold and treated with nitrous fumes (from arsenious oxide and nitric acid), nitrosomethylurethane is formed:

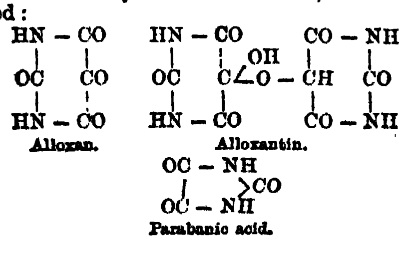
$$CO<^{N.NO.CH_3}_{OC_2H_5}.$$

It is washed with water, then with sodium carbonate solution, and dried over anhydrous sodium sulphate; its ethereal solution yields diazomethane (*q.v.*) when warmed with caustic potash in methyl alcohol solution.

Uric Acid (*Chem.*)

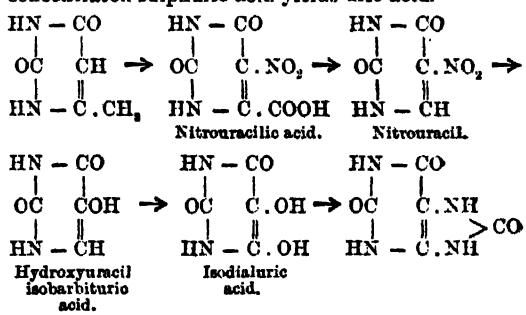


(2 : 6 : 8 trioxypurine. *See* PURINES.) A white crystalline powder when pure (rhombic plates); one part dissolves in about 16,000 parts of cold water or in 1,600 of boiling water; it is insoluble in the usual organic solvents (alcohol, ether, etc.), but is said to dissolve in warm glycerine. When heated it decomposes without melting, giving off a smell of burnt feathers, and forming ammonia, urea, cyanic and cyanuric acids. Uric acid reduces Fehling's solution. When carefully oxidised by nitric acid, uric acid gives alloxan and urea; further oxidation gives parabanic acid (*q.v.*); if the oxidation is effected by dilute nitric acid, alloxantin is formed:



Alloxan. Alloxantin. Parabanic acid.

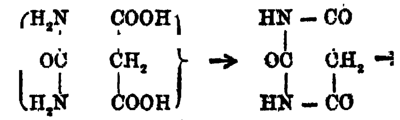
On adding ammonia to the residue obtained by evaporating uric acid with nitric acid on the water bath, murexide is formed. Murexide is the ammonium salt of purpuric acid (*q.v.*) This is an important test for uric acid. Uric acid is a weak dibasic acid, and forms three series of salts; *viz.* $C_5H_2M_2N_4O_3$ (normal salt); $C_5H_3MN_4O_3$ (biurate); $C_5H_3MN_4O_3 . C_5H_4N_4O_3$ (quadriurate), where M is a monovalent metal or base. The alkali urates are more soluble in water than uric acid itself, but the normal salts are resolved by much water into biurates. The urates of certain organic bases are also far more soluble in water than uric acid; *e.g.* piperazine (*q.v.*), which is used as a remedy (probably useless) in gout. Lithium biurate is very soluble in water—hence the use of lithium salts in gout, but their value as a remedy is doubtful. Uric acid is completely precipitated from its solutions by saturating the latter with ammonium chloride; the precipitate consists of ammonium biurate, which is quite insoluble in a saturated solution of ammonium chloride—basis of a method of estimating uric acid in urine. The acid occurs in urine—a healthy adult excretes from 0·2 to 1·25 grams in twenty-four hours; it is a common constituent of urinary calculi; in the blood of gouty persons it occurs as sodium biurate; it also occurs in the excreta of birds and serpents. Uric acid can be prepared from the excrement of serpents, hens, or pigeons by the following process: The material is dissolved in 5 per cent. caustic potash solution and boiled as long as ammonia escapes; a rapid stream of carbon dioxide is passed through the filtered solution till it is nearly neutral; the acid potassium urate thus precipitated is filtered, washed, dissolved in hot dilute caustic potash and poured into excess of hydrochloric acid. If the precipitated acid is still coloured, the process is repeated on it. Uric acid has been synthesised—(1) from methyl uracil (*see* ETHYLACETOACETATE), which is simultaneously oxidised and nitrated by nitric acid; the potassium salt of nitrouracilic acid loses carbon dioxide when boiled with water, and the resulting nitrouracil on reduction with tin and hydrochloric acid gives aminouracil and hydroxyuracil. Bromine water oxidises both these compounds to isodialuric acid, and the latter when heated with urea and concentrated sulphuric acid yields uric acid.



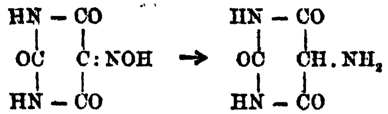
Nitrouracilic acid. Nitrouracil. Hydroxyuracil isobarbituric acid. Isodialuric acid.

(2) From malonic acid and urea, which condense under the influence of phosphorus oxychloride at 100° to the ureide of malonic acid (barbituric acid), which in solution is converted by potassium nitrite into isonitrosobarbituric acid (violuric acid)—a compound also formed by the action of hydroxylamine on alloxan. On reduction with hydriodic acid, violuric acid gives aminobarbituric acid (uramil), which on boiling with a solution of potassium cyanate gives pseudouric acid; the latter when added to melted

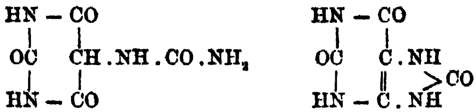
oxalic acid or when boiled with 20 per cent. hydrochloric acid gives uric acid:



Urea. Malonic acid. Barbituric acid.



Violuric acid. Uramil.



Pseudouric acid.

Uriconian Rocks (*Geol.*) A name given to certain Pre-Cambrian igneous rocks in the neighbourhood of the Wrekin. The name is derived from Uriconium, a Roman station. *See* PRE-CAMBRIAN ROCKS.

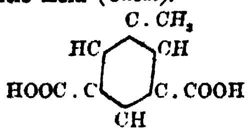
Urn (*Archæol.*) (1) A large kind of vase with an oviform or a rounded body standing on a foot; used as a receptacle for the ashes of the dead, as an electoral vase, etc. (2) A Roman liquid measure, equal to half the Amphora (*q.v.*)

Urticaceæ (*Botany*). A natural order of Dicotyledons, comprising the Nettles, and in some classifications the Mulberry and Elm. Many valuable fibres are obtained from plants of this order.

Ut (*Music*). The first of the sol-fa syllables. In England and many other countries *do* has been substituted for *ut* (*see* SOL-FA). *Ut bémol, C flat; ut dièse, C sharp.*

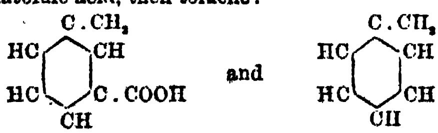
Uvic Acid (*Chem.*) *See* PYROTRITARIC ACID.

Uvitic Acid (*Chem*).

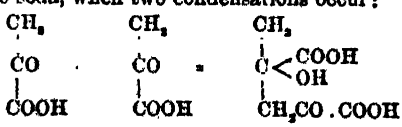


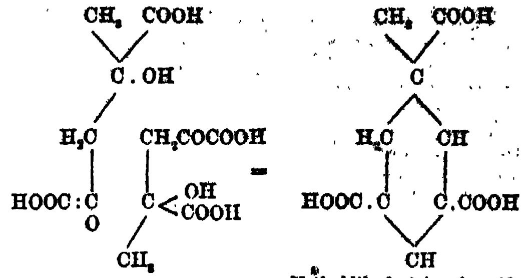
(Mesidic acid).

White needles; melts at 287°; soluble in alcohol and ether; when heated with quicklime it gives first metatoluic acid, then toluene:

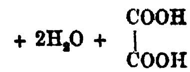


On oxidation with chromic acid it yields trimesic acid—the methyl group is oxidised to carboxyl (COOH). It is obtained by oxidising mesitylene (*q.v.*) with dilute nitric acid; it is also formed from pyruvic acid (*q.v.*) along with other acids by boiling with baryta water. The formation of uvitic acid from pyruvic acid is best effected by boiling with caustic soda, when two condensations occur:





Methyldihydrotrimesic acid.



Oxalic acid.

The methyldihydrotrimesic acid loses carbon dioxide and two atoms of hydrogen when added to hot concentrated sulphuric acid, and forms uvitic acid.

Uwarowite (*Min.*) A lime-chrome Garnet of emerald green colour from the Ural Mountains. *See* GARNET.

V (*Chem.*) The symbol for VANADIUM (*q.v.*)

V, v (*Phys., Eng., etc.*) A symbol for (1) Velocity, (2) Volume, (3) Potential Difference or Electromotive Force.

Vaccinium (*Botany*). A genus of the order *Ericaceæ*, represented in Britain by the Whortleberry, Cowberry, and Cranberry.

Vacuum. Theoretically, an empty space, containing no matter whatever. In practice, the term is applied to a space containing a small quantity of some gas at a very low pressure. The lowest pressure attained is less than the fifty-millionth part of an atmosphere.

Vacuum Brake (*Eng.*) A form of brake used on railway trains. The brake blocks are actuated by pistons working in exhausted cylinders, air being admitted on one side of the piston. The vacuum is produced by pumps on the locomotive. *See under* RAILWAYS.

Vacuum Gauge (*Eng.*) A gauge which measures the gaseous pressure in a partially exhausted space, or, more usually in the case of steam engines, the difference between the pressure of the atmosphere and that of the gas, etc., inside the space under consideration. This difference of pressure may be expressed in pounds per square inch, or in inches of mercury, just as the atmospheric pressure is.

Vacuum Pump. *See* AIR PUMP.

Vacuum Tube (*Phys.*) A tube containing a gas at a very low pressure (*i.e.* a so-called vacuum), usually fitted with electrodes by means of which the tube is connected to the secondary terminals of an induction coil. A very characteristic series of phenomena accompany the electric discharge which takes place through the tube, *e.g.* bands and striæ of light, and various forms of radiation, such as Cathode, Lennard, and Röntgen Rays. *See* RADIATION.

Vair. One of the heraldic "furs." It resembles a number of little shields placed in rows, the alternate ones reversed and of different tincture. The tinctures are argent and azure unless otherwise stated. *See* HERALDRY.

Valency (*Chem.*) (Quantivalence: Atomicity). The number of hydrogen atoms which can unite with one atom of an element A may be taken as one method of defining the valency of A. But some elements do not unite with hydrogen, and some others that do form compounds whose molecular weights are unknown. To meet this difficulty chlorine may be used to determine the valency of the element, as it is known that one atom of chlorine unites with one atom of hydrogen. Using one or other of these means we have—

MONOVALENT ELEMENTS (Monads):

H, ClH, BrH, FH, IH, $AgCl$, $InCl$.

DIVALENT ELEMENTS (Diads):

OH_2, SH_2, SeH_2, $ZnCl_2$, $HgCl_2$, $InCl_2$, $SnCl_2$, $PbCl_2$, $FeCl_2$, $CrCl_2$.

TRIVALENT ELEMENTS (Triads):

BH_3, NH_3, PH_3, AsH_3, SbH_3, $InCl_3$, $AlCl_3$, $BiCl_3$, $FeCl_3$, $CrCl_3$.

TETRAVALENT ELEMENTS (Tetrads):

CH_4, SiH_4, $SnCl_4$.

PENTAVALENT ELEMENTS (Pentrads):

PCl_5, WCl_5.

HEXAVALENT ELEMENT (Hexads):

WCl_6.

The compounds used in the above table to determine the valency of the elements are all gases or are capable of being gasified at a high temperature, so that all the above formulæ are correct either at the ordinary temperature or at a high temperature. It is seen at once that some elements have more than one valency, *e.g.* indium, tin, iron, chromium, phosphorus, tungsten. Again, while at moderately high temperatures the following compounds $SnCl_2$, $FeCl_2$, $CrCl_2$, $AlCl_3$, $FeCl_3$, and $CrCl_3$ (most probably) have the formulæ assigned to them, at lower temperatures they have a formula which is in all cases double the foregoing, *viz.* Sn_2Cl_4, etc., so that some elements alter their valency with the temperature. If this view be not taken, then it must be assumed that the simpler molecules in any one case unite with each other at lower temperatures, but are unable to do so at high temperatures; on this assumption the double molecules would be molecular compounds. In the above table the valency of sulphur, nitrogen, and lead are shown to be two, three, and two respectively. But the following compounds of these elements can all have their vapour densities determined, and are thus known to have the formulæ assigned to them:

SO_2, SO_3, SF_6, NH_4Cl, $Pb(CH_3)_4$;

and oxygen is divalent, fluorine, hydrogen, and chlorine monovalent, and the group CH_3 is methane (CH_4) less one hydrogen atom, and therefore also monovalent. Hence it must be concluded that sulphur may be divalent, tetravalent, or hexavalent; nitrogen trivalent or pentavalent, lead divalent or tetravalent. It is now seen that the valency of an element varies with the nature of the other element or elements with which it is united; and as sulphur trioxide breaks up on heating into the dioxide and oxygen the valency of this element changes with the temperature. In the case of the elements sodium, potassium, calcium, strontium, barium, compounds capable of being volatilised at temperatures suitable for vapour-density determination are not known (potassium iodide is an exception—in this compound potassium is monovalent), so that their valencies are decided from the results of analysis alone. For example, the result of analysis shows the composition of sodium chloride to be $NaCl$, but its true formula may be Na_2Cl_2 or Na_3Cl_3, etc. Now sodium is a metal of low melting point (96°) and chlorine is a gas, and it would seem unlikely that if sodium chloride had the formula $NaCl$ it would melt at a high temperature: for instance, silver melts at 961°, and silver chloride which has the formula $AgCl$ melts at 450°. In view of these facts sodium chloride, which melts at 815°, is more likely to have the formula Na_3Cl_3 which would make sodium trivalent

$$\begin{array}{c} ClNa \bigtriangledown NaCl \\ Na \\ | \\ Cl \end{array}$$

than $NaCl$. Thus it is seen that in the case of the important element sodium it is assumed rather than proved that it is a monovalent element, and a similar remark applies to all those metals which do not form vaporisable compounds. But it must be remarked that the sodium ion carries the same charge as a hydrogen ion, and so the ion is monovalent. In cases of this kind the Periodic System is of some service in determining valency—the metals of Group I. are monovalent or trivalent except in the case of copper, which is divalent. *See* PERIODIC SYSTEM. As another instance of the determination of valency in the case of non-vaporisable compounds, the case of tetravalent oxygen may be quoted. *See* OXONIUM COMPOUNDS. From the table it will be seen that nitrogen and carbon are respectively trivalent and tetravalent; but in the two compounds NO and CO these elements are almost certainly both divalent. To meet this difficulty these compounds may be called unsaturated: that is, the nitrogen and carbon are not acting in them with their highest valency, and they have therefore the power to unite with elements or groups sufficient to bring up their valency to three or five in the case of nitrogen and to four in the case of carbon. Now nitric oxide unites more readily with oxygen than with any other element, and we then get the compound NO_2, in which nitrogen is tetravalent; or it may be assumed that the compound N_2O_4 is formed first, in which the nitrogen is pentavalent, and that this breaks down with two molecules NO_2—that is, the valency of nitrogen changes from five to four. Carbon monoxide adds directly one atom of oxygen or two atoms of chlorine, and the carbon becomes tetravalent—CO_2 and $COCl_2$. In writing the formulæ for compounds, the valency of the elements concerned is generally represented by lines, every line attached to the symbol of an element representing its power to unite with one monovalent element or group. For example, $O=C=O$ means that carbon and oxygen are united together in such a way that one tetravalent carbon atom is united to two divalent oxygen atoms. Again,

$$\begin{array}{c} H-C-H \\ \| \\ H-C-H \end{array}$$

represents two tetravalent carbon atoms each united with only two monovalent hydrogen atoms and a divalent group $=CH_2$. In this latter case each carbon atom can unite with one monovalent atom or group and so become "saturated."

$$\begin{array}{c} H-C-H \\ \| \\ H-C-H \\ \text{Ethylene.} \end{array} + Cl_2 = \begin{array}{c} Cl \\ | \\ H-C-H \\ | \\ H-C-H \\ | \\ Cl \end{array}$$

The two lines between the two carbon atoms in ethylene are not intended to mean anything more than this. Two carbon atoms joined in this way are said to be "doubly linked." Similarly, in acetylene

$$\begin{array}{c} CH \\ ||| \\ CH \end{array}$$

the two carbon atoms are "trebly linked," meaning only that each carbon atom can unite with two suitably chosen monovalent atoms or groups, or their equivalents, as two hydrogen atoms and one oxygen atom

$$\begin{array}{c} CH \\ ||| \\ CH \end{array} + H_2O = \begin{array}{c} CH_3 \\ | \\ CHO \end{array}.$$

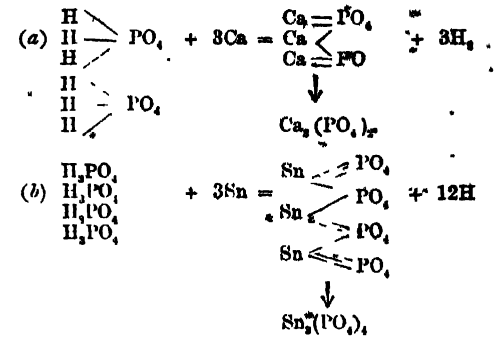
See UNSATURATED COMPOUNDS. There are many compounds whose existence seems to be incapable of explanation on the ordinary theory of valency: such are salts containing water of crystallisation—*e.g.* $CaCl_2 6H_2O$, and the complex compounds of salts of metals like cobalt and platinum with ammonia. Accordingly, it has been assumed that these are "molecular compounds"; that is, the molecules composing them are endowed with the property of uniting with each other just as the atoms of elements are, only there are no rules as to the valency of these molecules. Notwithstanding the inadequacy of the theory of Valency, it has rendered, and still renders, invaluable service to Chemistry. This arises from two causes. First, it is easily and accurately applied to exhibiting the constitution of salts, acids, and bases; and also the monovalent atoms and groups in these classes of compounds are those which in solution carry a charge of electricity equal to that carried by the hydrogen ion, while the divalent elements and groups carry twice that charge, and so on. Secondly, the valency of carbon is remarkably constant, probably owing to its electrically neutral character—it forms, in Series 1 of the Periodic System (*q.v.*), the border element, as it were, between the electropositive elements of Groups I., II., and III., and the electronegative elements of Groups V., VI., and VII. This constancy in the valency of carbon has contributed more than anything else to the development of Organic Chemistry. As to the nature of valency nothing is certainly known. For a valuable extension of the theory of valency, *see* WERNER'S THEORY. Two examples of the application of valency to the determination of formulæ are appended. (1) The formula for sulphur dioxide is SO_2. This may be written $O=S=O$. This gas unites, molecule for molecule, with chlorine, forming a stable compound, sulphuryl chloride, which will have the formula

$$O=\overset{\displaystyle Cl}{\underset{\displaystyle Cl}{\overset{|}{\underset{|}{S}}}}=O,$$

for the grouping —O—Cl would be unstable (Hypochlorite group). Sulphuryl chloride reacts with water in the proportion of one molecule of the former to two of the latter, giving sulphuric and hydrochloric acids: the only feasible way of representing this reaction is

$$O=\overset{\displaystyle Cl}{\underset{\displaystyle Cl}{\overset{|}{\underset{|}{S}}}}=O + \begin{array}{c} HOH \\ \\ HOH \end{array} = O=\overset{\displaystyle OH}{\underset{\displaystyle OH}{\overset{|}{\underset{|}{S}}}}=O + 2HCl,$$

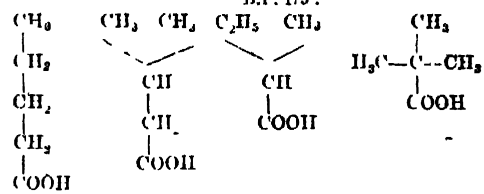
thus giving the constitution of sulphuric acid. (2) The formula for phosphoric acid being H_3PO_4, what will be the formula for calcium phosphate and stannic phosphate? Calcium is divalent, and tin in the stannic salts tetravalent, so we must have:



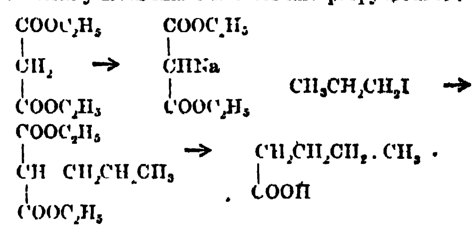
Valentenite (*Min.*) The orthorhombic antimonic oxide Sb_2O_4 (*cf.* SENARMONTITE). Antimony = 84·3, oxygen 15·7 per cent; often in acicular crystals of a white or greyish colour, with high lustre. It is an alteration product of other antimony ores, and occurs with them at numerous mines in Bohemia, Saxony, etc.

Valeric Acids (*Chem.*) $C_5H_{10}O_2$ (Valerianic acids). There are four of these acids:

I. Normal valeric acid B.P. 186°.	II. Isovaleric acid. B.P. 174°.	III. Methylethyl-acetic acid (contains an asymmetric carbon atom). B.P. 175°.	IV. Trimethyl-acetic acid. M.P. 35°, B.P. 163°.



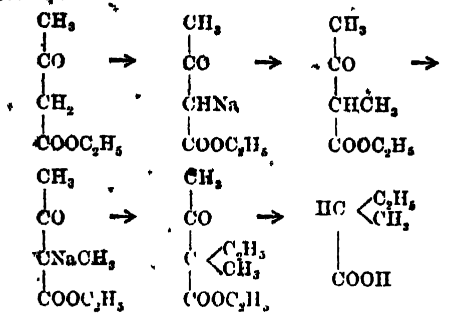
I. A colourless liquid; sparingly soluble in water; smells like butyric acid. It can be obtained synthetically from malonic ester and propyl iodide:



II. A colourless liquid; sparingly soluble in water; it has a disagreeable smell of old cheese: it is oxidised by chromic acid to acetic acid and carbon dioxide. It occurs in valerian root as bornyl ester, in the wild guelder rose and a number of other plants, as a decomposition product of proteids, and in perspiration. It is obtained, but not free from III., by oxidising amyl alcohol with potassium dichromate and sulphuric acid; a pure preparation can be obtained from malonic acid and isopropyl iodide (*cf.* I.) Its isoamyl ester smells of apples, and is used as a flavouring agent.

III. A colourless liquid; smells like II.; on oxidation it gives carbon dioxide and acetic acid. It is

known in all three forms (dextro-, lævo-, and inactive); the lævo-acid is obtained when amyl alcohol is oxidised. Synthetically it can be obtained either from ethyl malonate or ethyl acetoacetate:



The inactive acid so obtained can be resolved by brucine, the lævo-salt being the less soluble. The acid occurs in angelica oil, which is used in flavouring liqueurs.

IV. A white solid; sparingly soluble in water; smells like II. and also like acetic acid. It is prepared from tertiary butyl alcohol by converting it into the iodide, the iodide to nitrile, and hydrolysing the latter. *See also* STEREOCHEMISTRY.

Valley (*Build.*) The V-shaped hollow between two intersecting roof surfaces.

Valonia (*Botany*). The commercial name given to the unripe acorns of *Quercus Ægilops* (ordo., *Cupuliferæ*), used in tanning, and obtained from an oak grown in the Levant.

Valve (*Eng.*) A device for closing a pipe or passage in order to control, or entirely stop, the flow of a liquid or gas. *See* SLIDE VALVE, BALL VALVE, *etc.*

Valve Box, Chest, Casing, etc. (*Eng.*) The case or cover of a valve.

Valve Closet (*Sanitation*). This consists of a basin, with a circular outlet at its lowest part, closed by a watertight valve. This valve is hinged at one side and connected with the handle of the closet, so that when the handle is raised the valve is depressed into a metal box which is connected by means of a siphon or anti-D-trap with the soil pipe. A valve closet should not be flushed from a water-waste preventer, but from a small cistern holding from 6 to 8 gallons of water, so as to provide an "after flush," that is, a supply of water to remain in the basin. To secure this after flush it is usual to employ what is known as a "bellows regulator," a piston moving in a cylinder and connected with the handle of the closet and the valve of the supply pipe. The cylinder is provided with an air escape pipe, fitted with a tap, which regulates the rate at which the piston descends, and thus determines the amount of the after flush. When the handle is lifted the piston is raised, and the valve in the supply pipe is opened; but when the handle is released the water continues to flow until the piston falls and closes the valve. An overflow pipe, trapped, should also be provided to the basin, and to prevent siphonage this should be connected with the supply pipe by a branch pipe, so that the water is renewed every time the closet is used. It is also advisable to attach a ventilating or "puff" pipe to the valve box, so that when the handle is raised the foul air may escape into the open air instead of into the apartment.

Valve Diagram. A diagram showing the exact position of a slide valve, and consequently the opening of the ports of the engine, at any position of the stroke. There are several forms, due to REULEAUX, ZEUNER, etc., but they all aim at giving geometrical representation of the same facts.

Valve, Electric (*Elect. Eng.*) (1) Any mechanical valve operated by electrical means. (2) More usually, any conducting arrangement which permits a current to flow in one direction only, and which may therefore be used to rectify an alternating current. It may take various forms: *e.g.* a particular kind of electrolytic cell, or a suitably designed vacuum tube.

Valve Face (*Eng.*) The surface on which a valve rests or moves: applied especially to the surface on which a slide valve (*q.v.*) works.

Valve Gear (*Eng.*) The mechanism which moves the slide valve (or its equivalent) in an engine. *See* LINK MOTION.

Valve Rod (*Eng.*) A rod, one end of which is fixed to a valve, the other end passing out through a suitable stuffing box, and being acted upon by some form of valve gear.

Valve Seat (*Eng.*) The surface on which a valve rests: applied to disc, ball, and other forms of valve other than a slide valve.

Valve Sector (*Eng.*) The slotted link in the Link Motion (*q.v.*)

Valve Spindle (*Eng.*) (1) The rod by which a valve is moved. (2) The short rod (used in many disc valves, etc.) which guides the motion of a valve as it rises and falls.

Valve Spring (*Eng.*) A spring used to keep a valve in place, *i.e.* in contact with its seat, when it is not required to be open. Springs are commonly fitted to the disc valves used in many forms of petrol engines (*q.v.*)

Vamping (*Leather Manufac.*) An over swelling of the skin during the liming or drenching, sometimes termed "blowing."

—— (*Music*). Playing an extemporised accompaniment to a solo.

Vanadinite (*Min.*) A vanadate and chloride of lead, $3Pb_3V_2O_8 \cdot PbCl_2$. Hexagonal and isomorphous with Kampylite (*q.v.*) It is usually in short prisms or globular masses of a yellow or greenish colour. From Wanlockhead in Dumfriesshire, Siberia, Mexico, etc.

Vanadium (*Chem.*) V. Atomic weight, 51·2. A rare element coming between phosphorus and arsenic in Group V. of the Periodic System. In its physical properties it resembles a metal; but its chemical properties are those of a non-metal. It is obtained by reducing the dichloride in hydrogen at a bright red heat: oxygen, nitrogen, and water vapour must be rigidly excluded from the apparatus. So prepared, it is a crystalline greyish white powder; melts at 1,680°; specific gravity, 5·5; burns to the pentoxide when heated strongly in oxygen; heated in nitrogen it forms the nitride VN; heated in chlorine it forms the tetrachloride VCl_4; hot concentrated sulphuric acid oxidises it; nitric acid of any strength oxidises it. The element is widely distributed, but always in small amount; apparently it always occurs in the form of vanadates. Thus

vanadinite is $3Pb_3(VO_4)_2 . PbCl_2$, isomorphous with apatite, pyromorphite, minietisite (*see these*); mottramite, found in the Keuper (*q.v.*), in Cheshire, is $(Pb, Cu)_3(VO_4)_2 . 2(Pb, Cu)(OH)_2$. Five oxides are known—namely, V_2O to V_2O_5. None of them forms salts of the form V_mR_n, where R is the acid radical; but oxysalts such as hypovanadic sulphate, $V_2O_2(SO_4)_2$, a greenish blue powder, and vanadyl sulphate, $V_2O_2(SO_4)_3$, red crystals, are obtained—the first by dissolving the tetroxide in sulphuric acid and heating, and the second by dissolving the pentoxide in hot dilute (1:1) sulphuric acid. The most important oxide is the pentoxide, V_2O_5, which is obtained from mottramite by extracting the crushed sandstone which contains the mineral with hydrochloric acid and concentrating the acid solutions and washings, adding ammonium chloride and evaporating again till ammonium metavanadate crystallises out. This salt is repeatedly crystallised and finally heated—the pentoxide remains. To purify it, it is again converted into ammonium vanadate, and the latter decomposed by heat. It forms yellowish red prisms; melts without decomposition; sparingly soluble in water; with alkalis it forms vanadates—*e.g.* ammonia gives ammonium metavanadate, NH_4VO_3. The tetroxide, V_2O_4, is a blue crystalline powder, obtained by prolonged exposure of the trioxide to air; insoluble in water. The trioxide, V_2O_3, is a black powder, obtained by heating the pentoxide in hydrogen. The dioxide, V_2O_2, is a lustrous grey powder, obtained by passing the vapour of the oxytrichloride with excess of hydrogen through a red hot tube filled with charcoal; insoluble in water; soluble in acids, giving a lavender solution which readily absorbs oxygen and has strong bleaching properties. The existence of the monoxide is not established beyond all doubt. The VANADATES are derived from the pentoxide. No orthovanadic acid, H_3VO_4, is known; but metavanadic acid, HVO_3, forms golden yellow scales slightly soluble in water. It is obtained by adding excess of ammonium chloride to a solution of copper sulphate, then ammonium metavanadate (*see above*), till a precipitate is obtained; the whole is warmed to 75°, and the product is washed with dilute sulphuric acid, sulphurous acid, and water, and dried at 100°. It is used as a pigment under the name "vanadium bronze"; pyrovanadic acid, $H_4V_2O_7$, is also known. Hypovanadates are derived from the tetroxide; thus potassium hypovanadate, $K_2V_4O_9 7H_2O = K_2O . 2V_2O_4 7H_2O$, forms red-brown scales very soluble in water; it is obtained by adding excess of caustic potash to a concentrated solution of hypovanadic sulphate (*see above*). CHLORIDES: Tetrachloride, VCl_4, is a dark brownish red liquid; boils with partial decomposition to trichloride and chlorine at 154°; fumes in air; dissolves in water, forming a blue solution of hypovanadic chloride, $V_2O_2Cl_4$; it is obtained by passing the vapour of the oxytrichloride with excess of chlorine over pure charcoal heated to low redness. The trichloride, VCl_3, forms shining peach-blossom coloured tables similar to chromic chloride; it is deliquescent, and dissolves in water with a brown colour; soluble in alcohol, forming a greenish blue solution, and in ether forming a green solution; heated in air it forms the pentoxide; it is obtained by heating the tetrachloride or by heating the trisulphide in a current of chlorine and separating it from the sulphur chloride, which is also formed, by fractional distillation. The dichloride, VCl_2, forms apple-green lustrous hexagonal plates; it is deliquescent; soluble in alcohol and ether like the preceding compounds; reduced in hydrogen it yields the metal; it is obtained by passing the vapour of the tetrachloride mixed with pure hydrogen through a glass tube heated to low redness. The oxytrichloride, $VOCl_3$, is a yellow liquid; boils at 127°; vapour density normal; emits red fumes in air and is decomposed by water, forming pyrovanadic (?) and hydrochloric acids; it is obtained by heating a mixture of the pentoxide with charcoal in chlorine and redistilling the product over sodium in a current of carbon dioxide. Three sulphides are known—V_2S_2; V_2S_3; V_2S_5. The trisulphide forms shining black leaves, and is obtained by heating the trioxide in sulphuretted hydrogen or pentoxide in vapour of carbon disulphide. The other sulphides are obtained from the trisulphide by heating it in hydrogen and with sulphur respectively.

Van der Waals' Equation (*Phys.*) The equation which expresses the relation of the pressure (p), volume (v), and absolute temperature (θ) for a perfect gas—

$$pv = R\theta$$

is only approximately true for any known gas. A more complete representation is given by the Equation of Van der Waals—

$$\left(p + \frac{a}{v^2}\right)(v - b) = R\theta$$

in which a and b are two additional constants depending upon the particular gas.

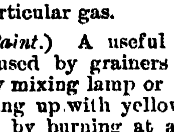
Vandyke Brown (*Paint.*) A useful pigment of a rich brown colour used by grainers and house painters, and made by mixing lamp or other black with red oxide and toning up with yellow ochre. A better quality is made by burning at a light heat cork cuttings, bark, etc. Vandyke brown is permanent, and works equally well in water, turpentine, and oil.

Vane (*Eng.*) A plate, arm, blade, or other device projecting from an axis for the purpose of being acted on by a moving current of air, water, etc., as in the case of a water wheel, turbine, windmill, etc.

——, **Wind** (*Meteorol.*) An arrow, or equivalent object, placed on a vertical support and free to turn horizontally. The direction the arrow points is the compass direction from which the wind is blowing.

Vanilla (*Botany*). The unripe fruit (Vanilla Bean) of the Mexican orchid *Vanilla planifolia* (order, *Orchidaceæ*) are dried, and afterwards treated with oil to retain the fragrance. An extract obtained from the bean is used for flavouring ices, confectionery, etc. Other tropical species, *e.g. V. grandiflora* and *V. aromatica*, are also employed, but are not equal in quality.

Vanillin (*Chem.*)

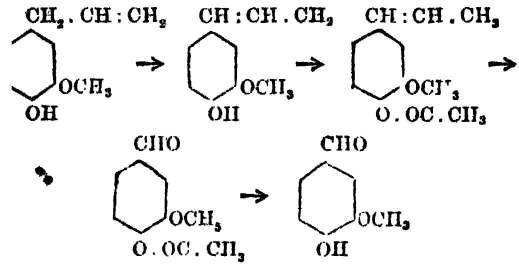


White needles; melts at 81·5°; boils at 285° (170° under a pressure of 15 mm. mercury); sublimes on heating; soluble in alcohol, ether, chloroform, hot petroleum ether, but slightly soluble in cold petroleum ether. The smell of vanilla is due to this substance, and vanilla pods contain about 2 per cent. of it; it is also found, but to a less extent, in gum benzoin from Siam and Sumatra. It is extensively used for flavouring confectionery and liqueurs. As an aldehyde it is easily oxidised to the corresponding

acid, vanillic acid, *e.g.* by moist air or by ammoniacal silver; sodium amalgam reduces it to vanillic alcohol and to hydrovanilloin

$$C_6H_3\left\langle\begin{array}{l}OH\\ OCH_3\\ CHOH\end{array}\right. . \left.\begin{array}{r}HO\\ H_3CO\\ CHOH\end{array}\right\rangle C_6H_3:$$

it yields an oxime and combines with sodium hydrogen sulphite. As a phenol it gives a colour reaction—blue—with ferric chloride; it gives an acetyl derivative with acetic anhydride. As an ether it splits off methyl chloride when heated in sealed tubes with hydrochloric acid. It can be extracted from vanilla pods, but is now made artificially in a variety of ways. (1) The glucoside coniferin occurs in the juice of the cambium of fir trees, and may be obtained by boiling the juice, filtering, and evaporating till the glucoside will crystallise out; the coniferin is then oxidised by rather dilute chromic acid, yielding a glucoside of vanillin, which, on hydrolysis by dilute sulphuric acid, yields glucose and vanillin, and the vanillin is extracted with ether. (2) Eugenol (*q.v.*) is converted into isoeugenol by boiling it with caustic potash in amyl alcohol for about twenty-four hours, distilling in steam to remove the alcohol, and liberating the isoeugenol with an acid; the isoeugenol is acetylated with acetic anhydride, oxidised with potassium permanganate in acetic acid solution, and the oxidation product hydrolysed by caustic potash; the vanillin is extracted with ether and purified by means of its sodium hydrogen sulphite compound:



Compare PIPERONAL. (3) From protocatechuic aldehyde (from catechol (*q.v.*) by Reimer's reaction (*q.v.*) by shaking with dimethylsulphate (Patented). (4) From guaiacol. *See* REIMER'S REACTION. There are several other ways of obtaining Vanillin.

Vanishing Point (*Painting and Drawing*). The point at which all the imaginary lines in the perspective of a picture or drawing converge: the intersection with the picture plane of a line or plane passing through the eye and parallel with the original line or plane, *i.e.* one in nature, etc.

Vapour *and* **Vapour Pressure** (*Phys.*) A vapour is best defined as a gas which can be condensed to a liquid by the application of pressure alone, without the necessity for lowering the temperature.

The actual gaseous pressure exerted by a vapour is termed the VAPOUR PRESSURE or VAPOUR TENSION. If the vapour be in contact with its liquid, this pressure attains a certain value, which depends only upon the temperature, and is termed the MAXIMUM VAPOUR PRESSURE, or SATURATION PRESSURE, and the vapour is said to be a SATURATED VAPOUR. If the space containing the vapour be diminished, some of the vapour will, in general, condense to a liquid, the pressure remaining constant; while an increase in the volume of this space is followed by additional evaporation which restores the pressure to its original value, so long as any of the liquid remains. When the liquid has entirely evaporated into the space, and the volume is increased, the vapour behaves to a great extent in a similar manner to a gas, *i.e.* the pressure falls. The vapour is now said to be UNSATURATED. The pressure may be increased if the supply of heat be further continued; the vapour rises in temperature, and is said to be SUPERHEATED.

So long as the space above a liquid is not saturated, vapour is continually given off, *i.e.* slow EVAPORATION occurs. If the liquid be heated, the vapour pressure rises and evaporation becomes more rapid. When the temperature has been raised sufficiently, the vapour pressure becomes at length equal to the superincumbent pressure, and bubbles of vapour are formed within the mass of the liquid itself. These bubbles rise to the surface and break, *i.e.* BOILING, or EBULLITION occurs.

The quantity of heat necessary to change unit mass of a liquid at any temperature into vapour at the same temperature is termed the LATENT HEAT OF VAPORISATION. This quantity varies with the temperature: for water, the value of the latent heat L, at a temperature t°C., is given by E. H. Griffiths as

$$L_t = 596{\cdot}73 - {\cdot}601\,t.$$

Vapour Pressure.—The pressure of a vapour may be measured in various ways. (1) Some of the liquid is introduced into the space above the mercury in a barometer tube and the consequent depression of the mercury is measured. (2) The boiling point of the liquid is observed at a known temperature.

Vapour Density.—There are several methods by which the density of a vapour may be determined. (1) DUMAS' METHOD consists in observing the mass of vapour which fills a bulb or globe of known volume at a known pressure and temperature. (2) VICTOR MEYER'S METHOD consists in observing the amount of air displaced from a vessel by the conversion into vapour of a small known quantity of the substance in a liquid form. The vessel is kept at a temperature above the boiling point of the liquid. (3) HOFMANN'S (*or* GAY-LUSSAC'S) METHOD depends upon the introduction of a known mass of the liquid into the space above the mercury in a barometer tube, as in the first method described under Vapour Pressure above.

Vargueno (*Furniture*). A seventeenth century Spanish cabinet serving the purpose of a secretaire, the body being box shaped and the front hinged at the bottom.

Variable Stars (*Astron.*) Stars which appear of different brightnesses or magnitudes at different times. Some are periodic, others are not. The periodic are divided into regular and irregular variables.

Variable Travel (*Eng.*) The travel, or distance moved through by a slide valve, can be altered at will in many forms of valve gear; *e.g.* with the ordinary link motion the travel can be varied from nothing up to the full "throw" of the eccentric by altering the position of the link. *See* LINK MOTION.

Variegated Yarn (*Textile Manufac.*) Fancy yarn composed of several colours, and the colours following in successive lengths. May be made on the spinning frame or the twisting frame.

Varnish (*Dec.*) Varnish is a liquid employed for improving the appearance and durability of a surface. On drying hard it usually has a lustrous shining coat, which resists the action of the air and moisture. Varishes are used in many trades, particularly by house and coach painters. They may be divided into two classes, SPIRIT VARNISHES and OIL VARNISHES. The former consist of a resin such as shellac, dissolved in alcohol, and become hard by evaporation of the spirit; they are not suitable for exposure to the weather. *Oil varnishes* are prepared from various gum resins, linseed oil, and turpentine. These are raised to a considerable heat in order to cause the gums to dissolve. The turpentine (*q.v.*) is added in order to "thin" the mixture and render it fit for application by a brush. The oil used in varnish making is almost invariably linseed oil (*q.v.*), but of late Chinese tung or wood oil has been successfully employed to a limited extent. The quality of varnish when properly made depends principally upon the gum resins used. The chief of these are animi, amber, benzoin, copal, dammar, clemi, kauri, mastic resin, sandarach, shellac, and thus (*q.v.*)

MANUFACTURE.—The process of making varnish, while comparatively simple, requires considerable practical experience in order to vary the operations according to the gums that are dealt with. It may be briefly explained thus: The gum resin is first sorted, cleaned, and crushed, and is then placed in the varnish pot or kettle, which fits in a circular hole in the floor of the melting chamber, under which is the fire pit. In most modern factories the pots are fitted with conical covers fixed to iron pipes, which communicate with a condensing apparatus where the fumes are got rid of. In the cover is a small hole through which a rod is placed, and this enables the operator to stir up the gum from time to time, and to ascertain when it is all melted. The temperature during the melting is from 500° to 650° F. When the gum is all melted—and this can readily be ascertained by an experienced operator—the lid of the pot is raised by means of a chain provided for the purpose, the pot is lifted on to a carrier and wheeled to the varnish room, where boiling linseed oil previously prepared is added to it, and the mixture is then cooked. The proportion of the oil and gum, as well as the degree of heat, vary considerably according to the grade of varnish that is being made. 500° F. may be taken as an average heat for ordinary varnishes of the best grade. Generally the more oil that is added the longer will the boiling take. It is seldom less than two hours, and may last for eight or ten. In the latter case a stout varnish will be the result, and an increased quantity of turpentine will be required to thin it to the right consistency. To ascertain when the oil and melted gum have completely combined, the stirrer is withdrawn from time to time and a drop of the varnish is allowed to fall on to glass, when it immediately cools and has a cloudy appearance if the materials are not fully incorporated. The varnish being now made, the pot is withdrawn and allowed to cool, either in the open air or an open building prepared for the purpose. The turpentine is then added and stirred in. The final process is to clarify the varnish. This is usually effected by simply storing it in tanks for a few months, and then pumping it to other tanks for the purpose of giving it those peculiar qualities which come only from age, new varnish being almost invariably most unsatisfactory. The best varnishes are often stored for several years, and it is important that an absolutely uniform temperature be maintained the year round.

COLOUR.—In some varnishes a very light colour is necessary, as for example those which are intended for use over white work, maple, etc. In others colouring matter is added such as dragon's blood, gamboge, annatto, turmeric, saffron, indigo, and certain of the aniline dyes.

GRADES.—Varnishes are made in a great variety of grades for different purposes, and although many house painters sometimes mix different grades together, the practice is to be strongly deprecated. The following are the names of some of the varnishes in common use: Hard carriage varnish, coating body, hard church oak, finishing body, elastic carriage, pale copal, crystal, mastic, white hard, violin varnish, Brunswick black, Berlin black, etc. There is also a variety of varnish termed FLATTING VARNISH, which dries without gloss, and is used with good effect to form a contrast with an adjacent lustrous surface, *e.g.* the stiles and rails of a door may be varnished in the ordinary manner, and the panels be flatted.

DEFECTS.—Many of the defects in newly varnished work may be attributed to conditions, changes in the temperature, or a humid atmosphere during the time the varnish is being applied. Thus a hall newly varnished will sometimes be found to be clouded on one side due to the door being opened and a current of cold air being admitted whilst the varnishing was being proceeded with. A well ventilated room, rather warm, kept at a uniform temperature with freedom from dust in the air, affords the best conditions for successful varnishing.—A. S. J.

Varnish (*Photo.*) A solution of resinous substances applied to the film of a negative to protect it from contact with the free silver nitrate in silver printing, and to resist the action of air and moisture.

Vascular Bundle (*Botany*). The term given to the longitudinal strands of the stem, root, and leaf. A bundle consists of conducting tissues (soft bast and wood) and in some cases of a formative tissue, cambium, in addition. *Cf.* CELL.

Vase. A symmetrical hollow vessel, decorative in character, generally high in proportion to its width, furnished with a foot, and either with or without handles. Vases are generally made of some kind of pottery, but sometimes of glass, metal, stone, or other material. Ancient Greek vases were used for the purposes of everyday life, and the subject or *motif* of the decoration was often a domestic scene, so that the study of this form of art has shed much light on various phases of the life of ancient Greece. The following are the chief characteristics of Greek vases dating from the seventh to the third century B.C.—(1) Early or Athenian Dipylon style: geometrical ornament and grotesque figures. (2) Corinthian style: Oriental in character and consisting of bands or zones of animals, real and fabulous, and foliage, with figured borders, painted generally in black or dull red, sometimes in violet. (3) Black figure style: the decoration is generally black, the figures being silhouettes drawn on the natural ground; certain details sometimes added in other colours. (4) Red figure style: red figures on a black ground characterise the Periclean age, the finest period of Greek art. The oldest surviving example of artistic vase is probably that numbered 22,559 in the 4th Egyptian Room at the British Museum. It is inscribed with the name of Meren-Rā (B.C. 3233). One of the most famous

examples is the Portland Vase, a glass cinerary urn found near Rome, in the so-called tomb of Alexander Severus, and now in the Gold Room at the British Museum. Scenes from the legend of Peleus and Thetis form the subject of the decoration, which is cut in cameo. (*See under* GLASS MANUFACTURE.) Among other famous examples may be mentioned a specimen of Chinese porcelain of the Ta Ming dynasty (A.D. 1426) in the Salting Collection, South Kensington; and "El Jarro," a winged vase of Hispano-Moresque origin, decorated with gold lustre arabesques, the ground being blue and white (in the Museum of the Alhambra). *See* AMPHORA, CALPIS, CANTHARUS, CRATER, CYLIX, CYATHUS, ŒNOCHOË, OXYBAPHON, PROCHOOS, STAMNOS, URN, POTTERY AND PORCELAIN.

Vaseline. A gelatinous, translucent, unctuous body derived from crude petroleum, and popularly known as petroleum jelly. It is prepared by subjecting a selected quality of crude petroleum to dry heat in iron vessels until the lighter portions are driven off in vapour, and there remains the heavier portions of oil in a highly concentrated state. After repeated filtering through bone black, vaseline is obtained in the form of a solid jelly which is odourless and of a white opal colour. It is perfectly neutral, and entirely free from taste. Three varieties are on the market, known respectively as "white," "blonde," and "red." White vaseline is used for internal administration, for external applications of a delicate nature, and other refined toilet purposes. It is also successfully employed as the vehicle for several caustic, disagreeable, and nauseating medicines such as quinine, iodine, chloral, etc. Vaseline is the base of many toilet preparations and ophthalmic pomades and salves, and it is most useful to surgeons. The blonde variety is most generally met with, and is used for all sorts of wounds, burns, bruises, etc. Red vaseline is employed for ordinary pharmaceutical ointments, for veterinary purposes, for preserving leather, etc. The word "vaseline" is the property of the Chesebrough Manufacturing Company, and in this country can only be lawfully applied to their preparations.

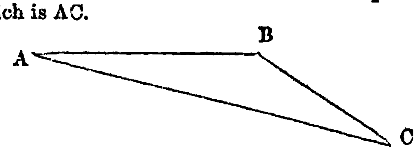
—— (*Chem.*) A semi-solid mixture of hydrocarbons chiefly of the paraffin series; melts at 35° to 50°; insoluble in water, sparingly soluble in alcohol, readily soluble in ether, benzene, chloroform. It is obtained from crude petroleum by distilling the lower boiling portions first, then further distilling under reduced pressure, heating by steam. The residue is then filtered through animal charcoal; the first portions of the filtrate form the colourless vaseline, the later portions are coloured yellowish brown with green fluorescence. Vaseline is employed as a lubricant, and in medicine in the preparation of some ointments.

Vat (*Paper Manufac.*) The wooden tank containing beaten pulp from which handmade sheets of paper are prepared.

Vatoe (*Silk Manufac.*) A sort of reed used by the turner-on in the process of beaming, to place the warp in its due order on the cane roll.

Vault (*Architect.*) (1) An arched ceiling or covering to a building or part of a building, usually constructed of brick or stone but sometimes of wood. (2) A subterranean apartment, whether arched or not. *See* BARREL VAULT, GROINED VAULT, RIB AND PANEL VAULT, *and* FAN VAULT.

Vectors (*Phys.*) A vector is a quantity which has direction as well as magnitude, *e.g.* Displacement, Velocity, Mechanical Force, Electric and Magnetic Force, Electric Current. To specify any such vector it is necessary to know (1) its numerical magnitude, size, or TENSOR, as this is sometimes termed, and (2) its direction or ORT, *i.e.* the angle which it makes with some specified or arbitrary line. The ADDITION OF VECTORS is not the simple addition of their numerical values; let a vessel sail a distance represented in magnitude and direction by AB, and from B a distance represented by BC; these two lines represent displacements, which are vectors, and the sum of those vectors is the resultant displacement, which is AC.



A further example of the addition of vectors is given in the process of finding the resultant of a number of forces (*see* GRAPHIC STATICS, *p.* 268). The theorems of the Parallelogram of Forces, Polygon of Forces, etc., are cases of the addition of vectors. The MULTIPLICATION OF VECTORS is of much importance. The SCALAR PRODUCT of two vectors is the product of their numerical values into the cosine of the angle between them. For example, if a force F act on a body which is displaced through a distance x at an angle θ with the direction of the force, the work done is equal to the scalar product of the two vectors F and n, *i.e.* to $Fs \cos\theta$. This quantity has no direction, *i.e.* it is not a vector, but a scalar quantity. The VECTOR PRODUCT of two vectors is a third vector at right angles to the plane containing the first two, and its magnitude is equal to the product of the numerical values of the first two, into the *sine* of the angle between them. The vector product is important in the theory of electricity, *e.g.* the force on a conductor carrying a current and placed in a magnetic field is a vector product. If the current be 5 absolute units, and the conductor carrying it be placed in a field of 1000 lines per square centimetre, so that it makes an angle of 60° with the direction of the lines of force, the mechanical force on the conductor is $5 \times 1000 \times \sin 60°$ dynes per unit length.

V Edges *or* **Vee Edges** (*Eng.*) When one part of a machine has to slide or move in a straight line over another part, it is usual to provide the fixed part with projecting edges whose cross section is of the form of the letter V. The moving portion is then formed with slots or grooves of corresponding shape, which fit the fixed edges or strips. The bed of a lathe, or the slides of a slide rest, are examples. In certain other cases the fixed V edges may be on the moving part, the grooves being then formed on the fixed portion. This is usually the case in large planing machines.

Vegetable Black (*Dec.*) A very light weight but intensely black pigment, consisting almost wholly of pure carbon. It is made at the same time as lamp black (*q.v.*), being selected from that part of the stove which is farthest away from the furnace in which various refuse oils, etc., are burned. Vegetable black is largely used in the manufacture of the finest printers' inks, black varnishes, and by decorators in their finest work.

Vegetable Ivory. *See* COROZO NUT.

Vegetable Oils. *See* OILS *and* LUBRICANTS.

Vegetable Tallow. A fat obtained from the seeds of the Chinese tallow tree (*Stillingia sebifera*). It is used to a limited extent in candle making, and has a specific gravity of 0·915, and melts at 43—46° C.

Vegetable Wax. *See* CARNAÜBA WAX.

Vehicle (*Paint.*) The medium or liquid with which pigments are mixed in order that they may be applied to a surface. *See* PAINTING *and* HOUSE PAINTING.

Veil (*Cost.*) A piece of fabric generally of light texture, worn over the face or head for protection or ornament; in the middle ages a circular or semicircular headdress or part of a headdress, falling over the head and shoulders.

Vein (*Geol.*) A fissure in the Earth's crust which has been filled with some rock or mineral of a different character and origin from the surrounding rock. In many cases veins are formed of igneous rock, *e.g.* Granite. *Cf.* MINERAL VEINS *and* METALLIFEROUS VEINS.

—— (*Zool.*) The term applied to the vessels conveying blood towards the heart. The walls are thin and easily distended, and the blood pressure in the veins is slow and variable. *See* ARTERY *and* HÆMOGLOBIN.

Vein Stuff (*Mining*). GANGUE (*q.v.*)

Velarium (*Archæol.*) A coloured awning supported by masts, to shelter the audience in a Roman theatre, etc.

Velloped (*Her.*) Having the gills of a different tincture from the body, *e.g.* as a cock.

Vellum (*Bind.*) A white and nearly transparent material, consisting of the membranous portion of calf's skin. Similar but superior to parchment, which is made from the skin of the sheep. Much used formerly in antique binding, and still used for expensive bindings, printings, etc. The term is also applied to materials manufactured from other substances.

Veloce; Velocita, Con (*Music*). Rapid.

Velocemente (*Music*). Rapidly.

Velocity of Sound (*Phys.*) Newton calculated theoretically that the velocity of sound in a medium should be equal to the square root of the elasticity, divided by the square root of the density, or

$$v = \sqrt{\frac{E}{\rho}}$$

Taking the isothermal elasticity in the case of a gas, $E = P$, this gives too low a value to be reconciled with the result of experiment. The explanation of this fact is that the adiabatic elasticity, $E = \gamma P$, should be taken; the correct equation is, therefore,

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Cf. ELASTICITY OF GASES.

Velum. *See* VELARIUM.

Velvet. A plain fabric with a fine pile or fur surface of silk, made from two warps. Three picks of weft having bound both warps by twill or tabby tie, the pole or pile warp is alone raised, and a grooved wire placed under it transversely, groove upwards. The weaving is proceeded with until three wires altogether are in the cloth, when the first wire is cut out by means of a sharp instrument, called a truvat, being drawn along the groove of the wire. This operation produces the pile. *See* WIRE.

Velveteen (*Cotton Manufac.*) A heavy backed fabric woven in the grey state and afterwards dyed. It has a surface composed of small weft floats arranged in regular order. These floats are afterwards cut so as to form a furry and silky pile, like velvet in appearance.

Velvet Finish (*Woollen Manufac.*) Velvet or vertical pile obtained by the process of raising on woollen fabrics, such as rugs. *See* PILE.

Vena Contracta (*Eng.*) A stream of liquid issuing from an opening has in general a diameter smaller than that of the opening. Such a jet or stream is termed a Vena Contracta. The amount of contraction depends upon the average angle at which the particles of the liquid are approaching the opening.

Venation (*Botany*). The system of branching and arrangement of the veins or vascular bundles (*q.v.*) in leaves.

Veneer. A thin layer of some valuable material, wood, ivory, mother-of-pearl, stone, etc., which is fixed to a commoner surface for the sake of effect. Veneers of wood are cut from the log by means of long knives or saws, the log being in some instances rotated in contact with the cutting edge, and are afterwards planed, shaped, and polished by machinery.

Veneer Cutter. *See* VENEER.

Veneering Hammer (*Cabinet Making*). A tool with a wide, thin pane, used for pressing out superfluous glue from beneath the veneer when it is being fixed in position.

Venetian (*Woollen or Worsted Manufac.*) A fine twilled cloth, usually twist warp, and made chiefly for covert coatings.

Venetian Blind. A blind made of laths of wood supported transversely by two or more tape ladders, and so arranged that when the blind is full open the laths lie in a horizontal plane and the series of openings admit light. By adjusting a cord, the laths can be turned at an angle so as to overlap each other and exclude light.

Venetian Glass. This is inferior to English glass in purity and lustre, but is capable of being made into lighter forms, for which it is noted. *See under* GLASS MANUFACTURE.

Venetian Red (*Dec.*) A pale red pigment largely used in house and coach painting, and resembling ochre or ferric oxide in composition according to the method adopted in its manufacture. Formerly the term Venetian Red was applied to a natural oxide of iron selected for its peculiar colour and being less purplish than Indian red. It is now almost wholly manufactured by calcining either green vitriol or ochre.

Venetian Shutter. A frame filled in with louvers (*q.v.*)

Venetian Swell (*Music*). The name given to the *swell* in organs. The shutters of the swell box are generally hung horizontally, and shut by their weight; when hung vertically they have a spring to shut them. Many organs have a balanced swell which enables the organist to leave the shutters at any angle. *See* MUSICAL INSTRUMENTS, *p.* 440.

Venetian Window (*Build.*) The name given to a window frame divided into three lights by mullions.

Venice Turpentine (*Dec.*) An oleoresin obtained from the common Larch, and used in varnish making. It is of a yellowish colour, is thick like honey, and is soluble in both essential and fixed oils, as well as in ether and alcohol. It melts at 808° F., and has a specific gravity of 0·856. *See also* TURPENTINE.

Venice White (*Dec.*) A white pigment made by mixing together equal parts of barium sulphate (barytes) and white lead.

Vent (*Foundry*). A narrow passage made by thrusting a wire into the sand of a mould to allow of the escape of gases while molten metal is being poured in. In certain cases where these openings are insufficient, actual pipes, termed VENT PIPES, are inserted.

—— (*Geol.*) *See* VENT, VOLCANIC.

Ventil (*Music*). (1) A valve letting in or cutting off wind from certain stops in organs. (2) A valve which when opened allows the wind to traverse a greater length of tube of brass instruments. *See* VALVE HORN, *p.* 435; VALVE TRUMPET, *etc.*

Ventilating Fan. A fan used either for forcing fresh air into a space, or for extracting foul air. *See also* SANITATION.

Ventilation. *See* SANITATION (p. 636), ASPIRATION, *and* CUBIC SPACE.

Ventilation of Sewers (*Civil Eng.*) This is best effected by vertical shafts of sufficient height above the ground to carry the noxious gases away from the traffic, and as far as possible away from houses: ordinary manholes and openings at the ground level are objectionable.

Ventilation of Tunnels (*Civil Eng.*) A long tunnel is most easily ventilated by means of shafts. In cases where the tunnel lies at a great depth (*e.g.* where it passes under a hill) shafts become impossible, and large fans may be used, as is the case in the Severn, Mersey, and Simplon Tunnels.

Ventilator. A specially constructed air passage in a building; a shaft in a mine, etc. For examples refer to ARNOTT'S VALVE, SANITATION (p. 636), *and* MINING.

Venting (*Foundry*). The formation of VENTS by thrusting a wire or thin rod, termed a VENT WIRE, into the sand of a mould. *See* VENT.

Vent Pipes (*Foundry*). *See* VENT.

Vent, Volcanic (*Geol.*) The opening or fissure through which volcanic products are ejected. The lava, etc., which filled the vent may remain as a solid core after every other trace of the original volcano has been removed by denudation, and ancient vents accordingly form very characteristic geographical and geological features.

Vent Wire (*Foundry*). *See* VENTING.

Venus (*Astron.*) The planet between the Earth and Mercury. Distance from Sun, 67,200,000 miles. Diameter, 7,700 miles. Periodic time, 0·62 years

Veratrine (*Botany*) An alkaloid used medicinally; obtained from *Veratrum* (a genus of *Liliaceæ*), and from another liliaceous plant, the *Cevadilla* (*Schœnocaulon officinale*).

Verde Antico. A green coating formed on the surface of ancient bronzes by the action of the elements. *See* PATINA.

Verdigris (*Chem.*) Is usually a mixture of basic copper acetates; blue verdigris is chiefly $CuO \cdot Cu(C_2H_3O_2)_2 \cdot 6H_2O$, while light blue and green products contain $Cu(C_2H_3O_2)_2 2CuO \cdot {}_2H_2O$. They are used as paints in the preparation of other copper containing paints, and to a small extent in medicine (externally). Verdigris is made in England by exposing plates of copper to the action of cloths which have been soaked in pyroligneous acid; the plates are then exposed to air, dipped in water, again exposed, and the product scraped off, the process being repeated till the copper is used up. The process requires several weeks.

Verditer (*Paint.*) A pale green pigment consisting of basic carbonate of copper. It is now but little used. Blue verditer is also made, and consists generally of copper carbonate, copper oxide, and copper sulphate. Being somewhat fugitive it is not much used.

Verdure (*Art.*) The term is applied to tapestry in which the design consists wholly or principally of trees or foliage.

Verge (*Archæol., etc.*) A rod, staff, or mace; used as an emblem of authority or as an ensign of office.

—— *or* **Pallet Arbor** (*Clocks*). The arbor, or spindle, to which the pallets are fixed. This arbor also carries the crutch, by means of which the impulse communicated to the pallets is transmitted to the pendulum.

Verge Board (*Build.*) *See* BARGE BOARD.

Vermiculate (*Architect., etc.*) Adorned with tracery having the character of the tracks made by worms.

Vermiform Appendix (*Zool.*) *See* CÆCUM.

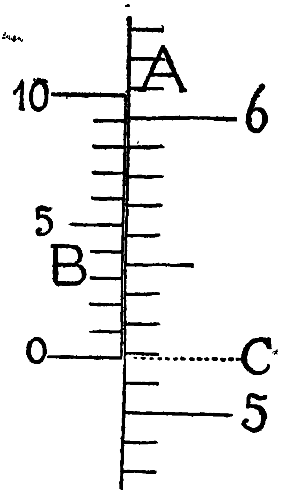
Vermilion (*Paint.*) A bright red heavy pigment made by heating sulphur and mercury. Its chemical name is mercuric sulphide. It was formerly used very largely in painting when a bright scarlet red was required, but it is now being gradually supplanted by the vermilionettes (*q.v.*) Vermilion has a good body, but is not quite permanent to light. A protective coat of varnish is therefore necessary when it is used for outside painting. The manufacture of vermilion in this country is a secret process which is very jealously guarded. Vermilion cannot be mixed with white lead because of the sulphur it contains. *See also* MERCURY COMPOUNDS.

Vermilionette (*Paint.*) A somewhat vague term, which is applied generally to a group of red pigments, mostly made from eosine, which are intended to be used as substitutes for vermilion. Vermilionettes are sold under a variety of names such as signal red, Markeaton red, fast red, post office red, etc. When protected by varnish the best vermilionettes remain almost permanent. Many of them, however, possess the disadvantage that they "bleed," *i.e.* come through any subsequent coat of paint which may be applied over them.

Vernal Equinox (*Astron.*) *See* EQUINOXES.

Vernier. A device to facilitate the accurate reading of a divided scale. It consists of a small movable scale, which is graduated in such a manner that $n + 1$ or $n - 1$ of its divisions are equal in length to n divisions of the original scale. Each division of the vernier is therefore less (in the first case) or more (in the second case) than a scale division, by $\frac{1}{n}$ of the length of a scale division. In the figure, nine divisions

of the scale A are equal to ten divisions of the vernier B. The zero line of the vernier is brought into such a position that it coincides with the point whose position is to be measured on the scale A; in the figure this point, which is marked C, lies between 5·1 and 5·2 on the scale. The graduation line 8 of the vernier coincides with the line 5·9 on the scale: it can be seen by inspection that the zero line of the vernier is ·8 of a scale division above the line 5·1 on the scale: hence the reading required is 5·18. In using this vernier the position of its zero line is first read to the nearest whole division on the scale, and the line on the vernier which coincides with a line on the scale indicates the next decimal place. By this means a scale divided into tenths of the major scale division can be read with accuracy to hundredths. The smallest length which can be read off on the vernier is termed its LEAST COUNT; if n divisions of the vernier are equal in length to $n + 1$ or $n - 1$ divisions of the scale, the least count is $\frac{1}{n}$ of a scale division, since this is the actual difference between one scale division and one vernier division.



Verschiebung, Mit (*Music*). The equivalent in German for *una corda*; *ohne verschiebung* being the equivalent for *tre corde*.

Verse (*Music*). Those portions of a service or anthem which are to be sung by one performer to each part. The other portions, except solos, are called the "full."

Versed Sine. *See* TRIGONOMETRICAL RATIOS.

Versin. VERSED SINE; *see* TRIGONOMETRICAL RATIOS.

Verso (*Print, etc.*) (1) The left-hand page; *cf.* RECTO. (2) The reverse of a coin or medal; *cf.* OBVERSE.

Vert. The heraldic tincture green. Represented by diagonal lines drawn from dexter chief to sinister base of the shield. *See* HERALDRY.

Vertebrata (*Zoology*). A division of the animal kingdom, characterised by having a backbone or vertebral column.

Vertical. Upright, in the direction along which gravity acts, or normal to the surface of a liquid at rest. A vertical line is easily found in practice by means of a fine cord carrying a weight, *i.e.* a plumb bob. The term vertical is often erroneously used instead of perpendicular or normal (*q.v.*)

Vertical Boiler (*Eng.*) *See* BOILERS.

Vertical Circle (*Astron.*) A great circle passing through the zenith and nadir of the celestial sphere. *See* PRIME VERTICAL.

Vertical Engine (*Eng.*) Any engine whose cylinder is vertical. *See* STEAM ENGINE.

Vertical Section. The section (*q.v.*) of an object by a vertical plane.

Vesica Piscis (*Architect.*) The name given to a figure obtained by the intersection of two circles. It is used in window tracery and other features in Gothic architecture.

—— (*Art*). A figure of pointed oval form, used as a symbol of Christ. An aureola used in representations of the Trinity or of the Virgin is generally of this form. *See* AUREOLA *and* GLORY.

Vesicular Structure (*Geol.*) A cellular structure found in lavas, slags, etc., in which a number of spherical cavities have been produced by steam or other gases before the consolidation of the rock.

Vestry. *See* SACRISTY.

Vesuvianite. (*Min.*) *See* IDOCRASE.

Veuglaire (*Arms*). A sixteenth century breech-loading cannon, having a detachable powder chamber.

Vexillum (*Archæol.*) A battle signal or flag, either fixed or carried by a vexillary (standard bearer).

—— (*Her.*) A scarf, encircling a pastoral staff.

Viaduct (*Civil Eng.*) A bridge consisting of a series of arches of masonry or other material, or some other form of structure, intended for carrying a roadway or railway (1) over a valley, etc.; (2) over some existing channel of communication.

Via Lactea (*Astron.*) *See* MILKY WAY.

Viameter (*Surveying*). A wheel with an arrangement for recording the distance passed over when it is rolled along the ground.

Vibrante (*Music*). Tremulous.

Vibration (*Eng.*) In engineering this term is usually applied to an intermittent or irregular motion, which is generally of an undesirable character, and is rarely used to describe any regular motion of the true character of vibrations.

—— (*Phys.*) A periodic movement of small extent which may take a great variety of forms, not confined to one plane.

Vibrator Roller (*Print.*) Used in connection with printing machines. *See* TYPOGRAPHY.

Vibrio (*Biol.*) Bacteria in the form of threads, with bent joints.

Vicar Choral (*Music*). A lay vicar of a cathedral choir.

Vice (*Eng.*) The tool used for holding the smaller pieces of work while being operated upon; it consists of a pair of jaws which can be caused to approach, or recede from, each other by a powerful screw or other device. There are very many forms and sizes.

Vice Bench (*Eng.*) A strong bench to which a vice can be attached.

Vicia (*Botany*). A genus of *Leguminosæ* represented by the vetch, the tare, broad bean, etc.

Victoria Green (*Dec.*) Another name for BRUNSWICK GREEN (*q.v.*) *See also* DYES AND DYEING.

Victoria Red (*Dec.*) A vermilionette (*q.v.*)

Vienna Lake (*Dec.*) Another name for CRIMSON LAKE (*q.v.*)

View (*Art*). A picture or sketch representing a landscape or seascape. *See also* PRIVATE VIEW.

View Finder (*Photo*). An instrument employed with hand cameras to show when the image will fall in the desired position on the sensitive plate.

View Meter (*Photo*). An instrument used for ascertaining the amount of subject included on a given size plate with the lens employed, without the necessity of setting up the camera.

Vignette. (1) In old manuscripts, an initial letter decorated with leaves and tendrils. (2) A head or tail piece in a book. (3) A drawing, photograph, or other illustration having a background that gradually shades off and merges into the ground on which the print is made.

Vignetting (*Photo*). A method of printing in which there is a gradual softening or shading off of the photograph towards the edges. This is effected by some form of mask or screen.

Vignoles Rail (*Civil Eng.*) *See* RAILWAYS, *pp.* 597-8.

Vigogne Yarn (*Woollen Manufac.*) Yarn composed of a mixture of cotton and wool.

Vigore, Con (*Music*). With vigour.

Vigorosamente (*Music*). Vigorously.

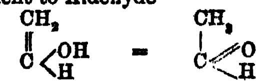
Villi (*Zool.*). Minute finger-like projections from the wall of the ileum. They project into the cavity of the intestine, and absorb the nutriment from the chyme.

Vinasse (*Chem.*) *See* TRIMETHYLAMINE.

Vine (*Botany*). The numerous products of the grape vine, *Vitis vinifera* (order, *Vitaceæ*), are well known. The dried fruits form raisins, and the small seedless berries of the black Corinth grape constitute currants.

Vinegar (*Chem.*) An impure dilute acetic acid. The amount of acetic acid varies from 4 to 15 per cent. Besides water and acetic acid other substances are present, and the nature of these depends on the method of manufacture and adulteration. Wine vinegar is made by allowing inferior wine to ferment in casks with good air access and at a proper temperature. This vinegar is pale yellow to red in colour, and contains a little alcohol, ethyl acetate, and other esters to which its aroma is due, and dissolved solids such as alkaline acetates, tartrates, and phosphates. Malt vinegar is made by allowing a wort such as is prepared in the manufacture of alcohol (*q.v.*), with some added alcohol, to drip over deal shavings covered with a growth of the mycoderma aceti (the organism which oxidises alcohol to acetic acid) and contained in a large oak tub; the supply of dilute alcohol must be regulated, a suitable supply of air provided for, and a proper temperature maintained. In starting such a process the shavings must have been coated with the organism first by allowing vinegar to stand in the tubs some days. A stronger vinegar is made by running the product with added alcohol through a second tub; but an acid over 15 per cent. cannot be prepared in this way, for the organism ceases to be effective in an excess of acetic acid. Such vinegar is usually coloured by caramel. Occasionally it is adulterated with a mineral acid, but this is illegal; it may contain traces of arsenic if the malt used in its preparation contained arsenic (from the fuel of the malt-kiln). An inferior vinegar is made from pyroligneous acid (*q.v.*). Vinegar is used to some extent in medicine, *e.g.* for sprains, and in fevers (lowers the temperature and checks perspiration).

Vinyl (*Chem.*) A name given to the group $CH_2{=}CH$; thus vinyl bromide is $CH_2{=}CHBr$, and vinylamine is $CH_2{=}CHNH_2$. Vinyl alcohol is not known, as it undergoes rearrangement to Aldehyde



Viol da Braccia; Viol d'Amore; Viol da Gamba (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 427.

Viola (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 427.

Violet (*Colours*). Most of the violet colours now used are made from the anilines which are precipitated on a white base. None of them are quite permanent.

Violin (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 427.

Violin Diapason (*Music*). A metal organ stop of small scale and stringy tone.

Violino Principale (*Music*). The leader of the orchestra.

Violino Ripieno (*Music*). Violin parts required for filling in or strengthening the *tutti*.

Violle (*Light*). A unit of intensity of light. It is equal to the intensity of illumination emitted (in a perpendicular direction) by one square centimetre of platinum at the temperature at which it melts.

Violoncello (*Music*). A metal organ stop in the pedal organ of 8 ft. tone. It is the octave of the violone. *See also* MUSICAL INSTRUMENTS, *p.* 427.

Violone (*Music*). A metal organ stop in the pedal organ of 16 ft. tone. It is an open Diapason or Gamba of small scale.

Virginal (*Music*). The name applied in England during the sixteenth and seventeenth centuries to all kinds of musical keyed-instruments played by quills or jacks, but more especially to those of the Elizabethan period; *e.g.* the spinet, harpsichord, etc.

Virtu, Vertu (*Art*). This terms refers generally to decorative objects that are either old, rare, or curious; *objects of virtu.*

Virtual Current (*Elect.*) The effective value of an alternating current depends not upon its average value, but is equal to the square root of the average value of the square of the current. Thus if C_0 be the maximum value of a current following a sine law, C the value at any instant t, $C = C_0 \sin \theta$, and the virtual value, $\overline{C}$, is given by the equation

$$\overline{C} = \frac{C_0}{\sqrt{2}}.$$

Virtual Image (*Phys.*) If rays diverging from a point A behave after reflection or refraction as if they diverged from a second point B, then B is a Virtual Image of A.

Virtual Voltage (*Elect. Eng.*) The square root of the mean value of the square of the voltage of an alternating current. If the E.M.F. vary according to

a sine law, and V_0 be the maximum voltage, V the virtual voltage, then

$$V = \frac{V_0}{\sqrt{2}}.$$

Cf. VIRTUAL CURRENT.

Virtuoso; *pl.* Virtuosi (*Art*). One who has a critical knowledge of the fine arts, or of some branch of the fine arts; an art critic. *Cf.* CONNOISSEUR.

Viscose. A soluble form of cellulose obtained by treating the cellulose with alkali and bisulphide of carbon. *See* CELLULOSE *and* WOOD PULP.

Viscosimeter *or* **Viscometer.** *See* VISCOSITY.

Viscosity. The property possessed by a liquid of resisting deformation. The fact that liquids do resist attempts to alter their shape becomes noticeable when a liquid is transferred from one vessel to another through a tube; it must then temporarily assume the form of the interior of that tube. In many cases the resistance of a liquid (take castor oil as an excellent example) to deformation can be observed by simply tilting a wide bottle containing some of it. The liquid assumes the new form thereby given to it sluggishly and reluctantly. This resistance is called viscosity. Being often associated with weight and stickiness, it is confounded with these properties, especially with the latter, although it has nothing to do with either of them. The words "viscous" and "viscosity" nevertheless are derived from *viscum*, the Latin word for birdlime. The opposite of viscosity is mobility. We speak of water or alcohol as mobile liquids, of castor oil or fused butter as viscous liquids; but the difference is one of degree only, and there are liquids so viscous and solids so plastic that we see what thin partitions divide the solid from the liquid, and that the distinction between the two is arbitrary, and one of convenience merely. A mobile liquid may be defined as one which resists change of form so little that the human eye cannot notice the resistance. The practical significance of viscosity is very great in respect of lubricants, all of which possess a perceptible degree of viscosity. The usual standard of measurement is rape oil. The viscosity is measured by the time which the known volume of the liquid takes at a given temperature to flow through an aperture of known form and dimensions under a known mean pressure. The instrument used for comparing viscosities is called a VISCOSIMETER (or, by a shortened form, VISCOMETER). Redwood's viscometer, which is a good type, consists of a silvered copper cylinder about 2 in. in diameter and about 4 in. deep, to receive the liquid to be tested. The liquid flows out at the bottom through an agate jet, which is opened by raising a valve by means of a vertical spindle. The support of this spindle also carries a thermometer to ascertain the temperature of the liquid under examination. The cylinder is immersed in a jacket, whereby it is maintained at a constant temperature. Inside the cylinder there is a mark, so that the liquid can always be filled to exactly the same depth. The whole instrument is mounted on a tripod with levelling screws, so that the axis of the cylinder may be made truly vertical. This is essential to the proper outflow from the jet. A 50 c.cm. flask is put below the jet, and the exact time required to fill it to the mark is accurately noted. The following are a few illustrative examples of the time taken:

	Seconds.
Water	28
Cocoanut oil	64
Linseed oil	212
Walnut oil	232
Safflower	249 to 294
Poppy seed oil	254 „ 259
Earth nut oil	307 „ 429
Garden cress oil	322
Radish seed oil	385

A. S. J.

Viscountess (*Build.*) A roofing slate measuring 18 by 10 in. *See* SLATES.

Visible Horizon. The irregular line where the sky appears to meet the most distant visible objects on the earth's surface. *See also* OFFING.

Visor (*Arm.*) The front part of a helmet containing the openings for seeing and breathing. The visor was sometimes movable and sometimes otherwise.

Vitreous Copper Ore (*Min.*) *See* COPPER GLANCE.

Vitreous Electricity. Electricity of the same sign as that obtained by rubbing glass with silk; positive electricity.

Vitreous Rocks (*Geol.*) Eruptive rocks having a glassy structure and appearance, *e.g.* OBSIDIAN (*q.v.*)

Vitriol, Blue (*Min.*) *See* CHALCANTHITE.

Vitriol Chamber (*Chem. Eng.*) The "chamber" used in Sulphuric Acid Manufacture (*q.v.*)

Vitriol, Green (*Min.*) *See* COPPERAS.

Vitriols (*Chem.*) Crystallised sulphates of copper, iron, zinc. See under compounds of these metals. Oil of vitriol is sulphuric acid (*q.v.*)

Vittæ (*Botany*). The oil ducts found on the fruits of Umbelliferous plants.

Vivace, Vivo (*Music*). Lively.

Vivianite (*Min.*) A hydrous ferrous phosphate, $Fe_3P_2O_8 + 8H_2O$. Contains ferrous oxide 41·2, phosphoric acid 31·2, water 27·5 per cent. Monosymmetric, in sheaves of diverging crystals, green to indigo blue. In association with other iron ores in the mines of Devon and Cornwall, and in many foreign localities. Also in peat bogs, old drain pipes, and some clays.

Vizor. *See* VISOR.

V Joint (*Carp. and Join.*) A joint between two boards, of which the edges to be joined together are chamfered.

Vocalisation (*Music*). *See* SOLFEGGIO.

Vocal Score (*Music*). *See* SCORE, *p.* 647.

Voce di Petto (*Music*). The chest voice.

Voce di Testa (*Music*). The head voice.

Voice (*Music*). Voices are of seven kinds, *viz.* bass (the lowest), baritone, tenor, alto or counter-tenor—these four are men's voices—contralto, mezzo-soprano, and soprano (the highest)—these three are women's voices. Boys' voices are generally called treble. *See also* STAVE, *p.* 710.

Voicing (*Music*). The art of obtaining a particular quality of tone in an organ pipe and of procuring uniform strength and quality throughout the entire

stop. Voicing is one of the most delicate and artistic parts of the organ builder's art, and it is seldom, if ever, that a "voicer" is good at both "flue" and "reed" voicing.

Void (*Build.*) An opening or empty space, *e.g.* the opening spanned by a beam, arch, rafter, etc.

Voix Celeste (*Music*). A stop on organs and harmoniums producing a tone of a waving character. *See pp.* 441 *and* 443.

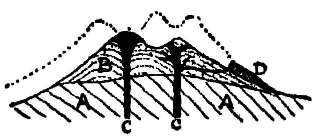
Volante (*Music*). Flying.

Volatile Alkali (*Chem.*) An old name for AMMONIA (*q.v.*)

Volcanic Ash (*Geol.*) Dust, scoriæ, and cinder-like fragments ejected from a volcano; this material may become consolidated in various ways into a more or less coherent rock, generally termed a TUFF.

Volcanic Rocks (*Geol.*) A general term for LAVA, TUFF, etc. (*q.v.*)

Volcano (*Geol.*) A volcano is essentially an opening in the crust of the earth, from which are ejected lava, fragments of rock, dust, steam, and sometimes other gases. The accumulation of the solid materials round the mouth of the opening, or CRATER, gives rise in most cases to a more or less permanent cone, which is often spoken of as the volcano itself. The lower part of the opening, or vent, extends downward for an unknown distance, and finally communicates with a region of molten or intensely heated materials. No smoke, in the proper sense, is poured out from a volcano, the dense clouds of steam, heavily charged with dust, simulating the appearance of smoke; and the reflection of the glowing lava of the crater often adds the appearance of flame and fire, though neither of the latter occurs. It follows therefore that the old definition a "burning mountain" is incorrect. The majority of active volcanoes are found in lines following the sea coast, *e.g.* on the western shores of the American continent, or the north-eastern shores of the Indian Ocean. The illustration shows a more or less diagrammatic section through the extinct volcanic remains of Largo Law in Scotland.



VOLCANO.

A. Original Rocks (Carboniferous).
B. Tuffs.
C. Basalt filling the vents.
D. Lava Sheet.

Volonte, à (*Music*). At will or pleasure; the equivalent of *ad libitum*.

Volt (*Elect.*) The unit of electromotive force employed in practice. It is that electromotive force which when applied to a conductor whose resistance is 1 Ohm (*q.v.*) produces in it a current of 1 Ampère (*q.v.*) The E.M.F.'s of most of the ordinary primary cells lie between 1 and 2 volts.

Volta (*Music*). Time. *Prima volta*, first time (*see* PRIMA); *seconda volta*, second time (*see* SECONDO).

Voltage (*Elect. Eng.*) Potential difference, usually expressed in Volts.

Voltaic (*Elect.*) An old term applied to electric phenomena produced by the current obtained from batteries.

Voltaic Cell (*Elect.*) *See* CELLS, PRIMARY.

Voltameter (*Elect.*) A piece of apparatus in which chemical decomposition is effected by the passage of an electric current; if the amount of such decomposition be measured, *e.g.* the volume of a gas given off, or the weight of a metal deposited on the Kathode, the quantity of electricity which has passed through the cell can readily be calculated.

Volti (*Music*). Turn; as *volti subito*, turn quickly.

Voltmeter (*Elect.*) An instrument for the direct measurement of voltage or potential difference. The main types of voltmeter are as follows:

(1) *Magnetic Voltmeters.*—These are in principle high resistance galvanometers, constructed either with a fixed coil and moving magnet, or preferably with a fixed magnet and moving coil. The moving part is provided with a pointer moving over a scale graduated in volts, by which the potential difference between the two points to which the terminals of the instrument are connected, may be read off. As the direction of the deflection depends upon the direction of the current, these types are only suitable for continuous currents.

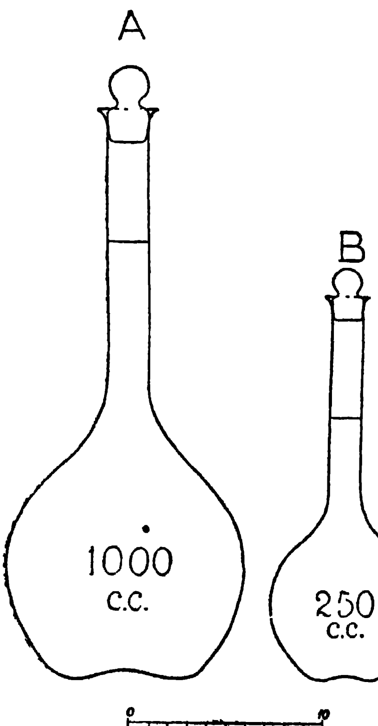
(2) *Hot Wire Voltmeters.*—In these the expansion of a thin wire of high resistance, when heated by the passage of a current, is caused to move a pointer. Cardew's Voltmeter is one of the best known forms. Such instruments are equally suitable for alternating or for continuous currents.

(3) *Electrostatic Voltmeters.*—These depend on the principle of the Electrometer (*q.v.*), which itself forms a voltmeter applicable to many purposes. In commercial instruments, the moving needle is attached to a light pointer, as in the cases above mentioned. Where great sensitiveness is required, a number of needles or vanes are mounted upon one shaft, and a corresponding number of fixed vanes or quadrants are arranged so as to produce simultaneously an attraction on the moving vanes. Voltmeters of this type possess many advantages over the two former kinds and are much used in alternate current work.

Volumetric Analysis (*Chem.*) Suppose we have two substances A and B which react in solution in exact accordance with a known equation. Then, if the end of the reaction can be easily determined by inspection or by the addition of a small amount of an indicator (*q.v.*), knowing the strength of the solution of A, the strength of the solution of B can be determined by finding what volume of the solution of A, must be added to a known volume of the solution of B in order to obtain a solution which contains excess of neither A nor B. An operation of this kind is a volumetric analysis. It will be seen that a reaction to be employed in volumetric analysis must be rapid and complete, that a balance and measuring instruments are required, that in those cases where the end of the reaction cannot be told by inspection an indicator is required, and that one of the solutions employed in any particular operation must be of known strength. Some of the typical reactions employed will be given further on. The measuring vessels commonly in use are:

(1) FLASKS.—These are pear-shaped or round, and have rather long necks; they should have well-fitting glass stoppers. On the neck there is a circular file mark, so that when the flask is filled up to the mark it will contain the volume marked on the vessel at the temperature marked on the vessel. Sometimes there are two marks on the neck of a flask; in this case the lower mark means that when the flask is filled up to this it contains the volume marked on

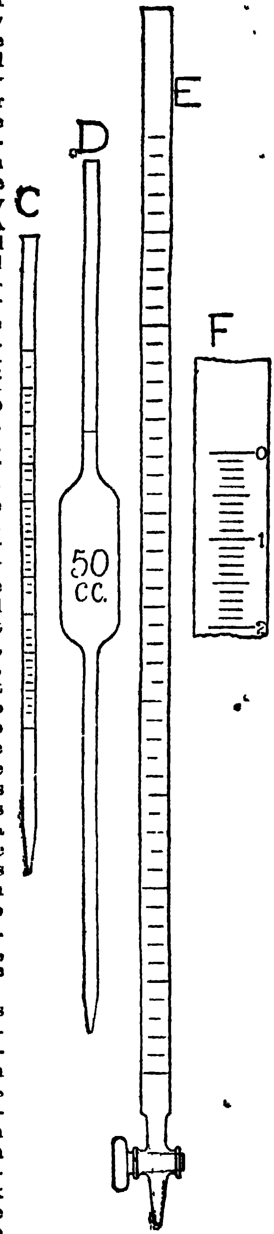
the flask, while the upper mark means that when the flask is filled up to this it will deliver, when it is emptied, the volume marked on the flask—the volume of liquid between the two marks is the amount of liquid that remains adhering to the walls of the vessel when it is emptied. The necks of the smaller flasks are narrow, so that the surface of the liquid in the neck is markedly curved, therefore in filling the flask up to the mark it is done so that the tangent plane to the lowest point of the curve lies in the plane of the circular file mark on the neck. Obviously the final adjustment of the liquid to the mark must be made with the file mark held on a level with the eye of the experimenter. These remarks as to the curved surface and reading apply equally to burettes and pipettes; also the neck of a flask, a burette, and a pipette can only be read accurately when vertical. Convenient sizes for flasks are 2 litres, 1 litre, 500 cc., 250 cc., 200 cc., 100 cc. Flasks A and B of 1,000 cc. and 250 cc. content are shown in the diagram drawn to scale.



FLASKS.

(2) BURETTES.—A burette is a straight tube open at one end and narrowed at the other end to an almost capillary tube; near the narrowed end there is a glass tap, or other device for regulating the flow of liquid from the burette. Starting a few centimetres from the wide end are file marks at every tenth of a centimetre down to 50 cc.; in the best burettes the uppermost file mark goes completely round the burette, at 0·5 cc. the mark goes about a third of the way round, at 1 cc. completely round, and so on all the way down. Smaller burettes are used sometimes. E is a 50 cc. burette; each division represents 1 cc., the subdivisions being shown on a larger scale at F.

(3) PIPETTES.—These are of two kinds—bulb and straight. The first form consists of a cylindrical bulb, on to each end of which rather narrow tubes are sealed; the delivery end is narrowed to an almost capillary opening, while the other end is of uniform bore and marked at a convenient distance from the bulb with a file mark going completely round the tube. A pipette can be marked with a containing and a delivering mark—usually only the latter mark is required. The straight form is employed for delivering smaller quantities of liquid than the bulb form; it is merely a burette without a tap. Pipettes are used either to withdraw (containing mark) a definite volume of liquid from a known volume of it or to transfer (delivery mark) a definite volume of liquid from one vessel to another. Convenient sizes are 100 cc., 50 cc., 25 cc., 20 cc., 10 cc., 5 cc., 2 cc. The first five are usually bulb shape, the other two bulb or straight; in the latter case they are graduated in fractions of a centimetre just as a burette is, only a 2 cc. pipette may be graduated in twentieths of a centimetre or even less. D is a 50 cc. bulb pipette and C a 5 cc. straight pipette. E, D, and C are drawn to the same scale as A and B.



BURETTE AND PIPETTES.

One of the solutions employed in any process of volumetric analysis must be of known strength, and this is called the standard solution. But the strength of the standard solution is not chosen at random; in scientific work it is customary to make solutions having some simple relation to the gram molecular weight dissolved in 1 litre; but an analyst will often make a solution of such a strength as to bear a simple relation to the particular substance he desires to estimate. We shall only deal with the

former kind of solution. These are so made that equal volumes contain chemically equivalent amounts of the dissolved substances. A solution which contains 1 gram of replaceable hydrogen, or the chemical equivalent of this of the active element or group, dissolved in 1 litre of the solution is called a NORMAL SOLUTION; then any other solution can be expressed in terms of a normal solution by dividing the number of grams of the substance contained in 1 litre by the number of grams of the substance contained in 1 litre of a normal solution.

Examples.—Hydrochloric acid, HCl, has the molecular weight 36·5, so that 36·5 grams of hydrochloric acid contain 1 gram of replaceable hydrogen; therefore 36·5 grams of hydrochloric acid in a litre is a normal solution of this acid; 3·65 grams in a litre would be a deci-normal solution, and so on. Sulphuric acid, H_2SO_4, has the molecular weight 98, so that 98 grams of this acid contain 2 grams of replaceable hydrogen, therefore a normal solution will contain 49 grams of the acid in a litre.

Caustic soda, NaOH, has the molecular weight 40; in it the monovalent atom of sodium may be regarded as having replaced 1 hydrogen atom in 1 molecule of water, so that a normal solution will contain 40 grams of caustic soda in a litre. Sodium carbonate, Na_2CO_3, has the molecular weight 106; in it the sodium atoms may be regarded as having replaced 2 hydrogen atoms in carbonic acid, H_2CO_3, so that a normal solution will contain 53 grams of sodium carbonate in a litre. Potassium permanganate, $KMnO_4$, has the molecular weight 158, and behaves as an oxidising agent in presence of excess of sulphuric acid and an oxidisable substance in accordance with the equation

$$2KMnO_4 + 4H_2SO_4 = 2KHSO_4 + 2MnSO_4 + 3H_2O + 5O.$$

That is, $2KMnO_4$ gives 5 atoms of oxygen which are equivalent to 10 atoms of hydrogen, and hence a normal solution of potassium permanganate contains $\frac{2 \times 158}{10} = 31{\cdot}6$ grams per litre. The operation of finding what volume of a standard solution must be added to a known volume of a solution of unknown strength to bring about a definite change so that no excess of either of the dissolved substances remains, is called a titration. Some of the principal operations in volumetric analysis are the following:

1. A standard alkali is used to determine the strength of an acid. The standard alkali can be made by weighing out 53 grams of pure sodium carbonate, dissolving this in distilled water and making up to 1 litre by the addition of distilled water; or a clean piece of sodium could be weighed, thrown into water, and the solution of caustic soda so obtained made up to a suitable volume with distilled water.

2. The converse of 1—that is, a standard acid—is used to determine the strength of an alkali. The standard acid could be made by taking the specific gravity of a fairly concentrated acid, then by means of a table finding what volume of distilled water must be added to make a litre of a normal solution of the acid. For instance, if the density $\left(\frac{20^\circ}{4^\circ}\right)$ of some sulphuric acid is 1·2, it is only necessary to take 296·9 cc. of this acid and make it up to 2 litres to have a normal solution of sulphuric acid. Let some normal sulphuric acid be placed in a burette, and 25 cc. of a solution of sodium carbonate be placed in a flask; add 1 drop of methyl orange solution and run in the sulphuric acid till the liquid just shows pink; let 30 cc. of the acid be required. Thus 1 cc. of the carbonate requires $\frac{30}{25}$ cc. of normal sulphuric acid to neutralise it, and therefore the carbonate must be $\frac{30}{25}$ times normal $= \frac{30}{25} \times 53$ grams Na_2CO_3 per litre.

3. A standard solution of potassium permanganate is used to oxidise a solution of a ferrous salt of a solution of oxalic acid or of an oxalate. To make the standard permanganate 3·16 grams of the chemically pure substance are dissolved in water and made up to a litre to obtain a deci-normal solution. Such a solution may have to be "standardised"—that is, may have to have its strength verified. In this case chemically pure ferrous ammonium sulphate may be used to verify the permanganate; a known weight of this salt is taken dissolved in water and titrated in presence of excess of sulphuric acid against the permanganate. Suppose the weight of the iron salt to be so chosen that it should take precisely 50 cc. of $\frac{n}{10}$ permanganate to oxidise it, and we find that it requires 50·25 cc. of the permanganate prepared as above; then this permanganate is $\frac{50}{50{\cdot}25}$ times deci-normal $= {\cdot}995 \times \frac{n}{10}$. Let ·56 grams of a specimen of iron be dissolved in dilute sulphuric acid, the latter being in considerable excess. Run in some of the above permanganate till the pink colour of the permanganate just persists: let 99 cc. be required. Now we have

$2KMnO_4$ gives 5O in presence of sulphuric acid,

$$\text{and } 2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O,$$

that is $\underbrace{2KMnO_4}_{316}$ oxidise $10FeSO_4$, or are equivalent to 10Fe—that is, 1000 cc. $\frac{n}{10}$ permanganate are equivalent to 5·6 grams iron, or 100 cc. $\frac{n}{10}$ permanganate are equivalent to ·56 grams iron; therefore the specimen of iron contains 99 × ·995 per cent. Fe.

4. Solutions of sodium thiosulphate and of iodine (in water containing sufficient potassium iodide to keep it dissolved) are often employed in volumetric analysis. These react in accordance with the equation

$$2Na_2S_2O_3 5H_2O + I_2 = Na_2S_4O_6 + 2NaI + 10H_2O.$$

That is, 2 × 248 grams of crystallised sodium thiosulphate react with 2 × 127 grams of iodine or 248 grams of the former with 127 grams of the latter; and as iodine unites with hydrogen atom for atom, we have: A normal solution of iodine contains 127 grams per litre; a normal solution of sodium thiosulphate contains 248 grams of the crystallised salt per litre. To illustrate the use of the above reaction weigh out 0·435 grams of manganese dioxide into a small flask; add excess of pure strong hydrochloric acid, and pass the chlorine evolved into a considerable excess of potassium iodide solution, so that no chlorine escapes from the solution; then titrate the liberated iodine by a deci-normal solution of sodium

thiosulphate. Suppose 95 cc. of the thiosulphate are required. The following reactions occur:

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$
$$Cl_2 + 2KI = 2KCl + I_2$$
$$2Na_2S_2O_3{,}5H_2O + I_2 = Na_2S_4O_6 + 2NaI + 10H_2O.$$

so that $\underbrace{MnO_2}_{87}$ is equivalent to $\underbrace{2Na_2S_2O_3{,}5H_2O}_{2 \times 248}$

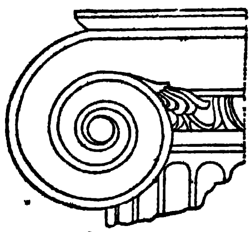
or 43·5 grams manganese dioxide require 248 grams crystallised sodium thiosulphate. Thus 0·435 grams of pure manganese dioxide would require 100 cc. of deci-normal thiosulphate; thus the sample contains 95 per cent. MnO_2.

5. A standard solution of silver nitrate can be used to find the strength of a solution of a chloride. In this case the silver nitrate is put in the burette and the chloride in a white basin; to the chloride a few drops of a solution of potassium chromate are added, and then the silver nitrate is run in. All the chloride is precipitated before the chromate, so that at the moment the precipitate is tinted by the brick-red colour of silver chromate the reaction is at an end, and a simple calculation gives the strength of the chloride. This operation is only possible with neutral solutions.

On the above and a few other reactions are founded a great variety of estimations by volumetric analysis. These processes of volumetric analysis are very accurate and far more rapid than those of gravimetric analysis, and are therefore extensively employed.

W. H. H.

Volute (*Architect.*) The spiral form used in the capitals of the Ionic, Corinthian, and Composite orders. A roughly formed volute is often found in Romanesque capitals.



VOLUTE.

Vorschlag (*Music*). A musical ornament, written as a small note or notes before the note which it embellishes. The time of the vorschlag is taken out of the embellished note. The long, short, and double vorschlag correspond respectively to appoggiatura, acciaccatura, and schleifer, which are all given under ORNAMENTS, *p.* 479.

Vortex Ring. A phenomenon of fluid motion, of which an example is found in the "smoke ring" which is produced by puffing smoke through a tube, or from the lips, or occasionally by steam from the spout of a kettle, or chimney of a locomotive. The fluid forming the ring is in a state of rotation about the centre of the cross-section of the ring itself. The mathematical theory of the properties of vortex rings is of great interest, but too complex for a short description.

Voussoir. One of the series of stones or bricks, fashioned like a truncated wedge, with which an arch is built. *See* ARCH.

Vox Angelica (*Music*). An organ stop consisting of two ranks of pipes of the dulciana type. One of them is tuned sharper or flatter than the other, thus producing a waving effect.

Vox Humana (*Music*). A reed organ stop of very small length and of peculiar construction, supposed to imitate the human voice.

V Thread *or* **Vee Thread** (*Eng.*) The ordinary screw thread of triangular section. *See* SCREWS.

Vulcan (*Astron.*) A supposed intra-Mercurial planet.

Vulcanite *and* **Vulcanising.** *See* RUBBER.

Vulned (*Her.*) Wounded. The pelican is sometimes represented as "vulning herself," in accordance with the idea that this bird feeds her young by pecking at her breast with her beak when she cannot otherwise provide for them. The pelican thus blazoned is also one of the emblems of the Catholic Church.

Vulpinite (*Min.*) A variety of ANHYDRITE (*q.v.*)

W (*Chem.*) The symbol for TUNGSTEN *or* WOLFRAM (*q v.*)

W, w (*Eng., Phys., etc.*) A symbol for Work.

Wad (*Min.*) A synonym for GRAPHITE (*q.v.*) used in the northern counties.

Wadding (*Textile Manufac.*) (1) A thick yarn used in compound cloths to give weight. It lies between the face and the backing threads. (2) Carded cotton in the form of sheets, used for filling out garments, and for other purposes.

Waggon Vault (*Architect.*) *See* BARREL VAULT, VAULT, *and* GROINED VAULT.

Wainscot (*Build.*) A lining for the inner walls of a building, generally extending a part of the way only from the floor to the ceiling. It is usually made of wood, panelled; but other materials, *e.g.* marble, are sometimes employed.

Wainscot Oak. Oak cut radially from the log in order to show the silver grain (*q.v.*)

Wald Flute (*Music*). A wooden organ stop of either 8 ft. or 4 ft. pitch. *See* p. 441.

Waling (*Build., etc.*) The horizontal timbers supporting the poling boards along the sides of a trench.

Wall (*Mining*). The side or boundary of a vein or lode.

Wall Bearing, Bracket, etc. (*Eng.*) A bearing, bracket, etc., so constructed that it can be fixed to, or built into, a wall.

Wall Plate (*Build.*) A horizontal bond timber supported by, or built into, a wall, and itself supporting the ends of joists and rafters. *See* FLOORS, *p.* 128, *and* ROOFS, *p.* 621.

Wall Rib (*Architect.*) A half or three-quarter rib used against a wall in Gothic vaulting. *See* RIB AND PANEL VAULT.

Walnut (*Botany*). The drupaceous (or stone) fruit of *Juglans regia* (*Juglandaceæ*). The stone or shell consists of two valves with leathery ingrowths between the cotyledons of the seed. A green pulp and rind surrounds the shell. *See also* WOODS.

—— (*Dec.*) *See under* GRAINING.

Warble (*Leather Manufac.*) A hole made in a hide or skin by the ox- or bot-fly.

Warehouse. A building for the storage of, or wholesale dealing in, goods.

Warehouse (*Print.*) The department of a printing office which controls the "white" or unprinted paper and the drying, pressing, quiring, etc., of the printed sheets.

Warm (*Paint.*) The term is applied to colours with a red or yellow tone; also to a picture in which these tones predominate, *e.g.* painted in *warm colours.*

Warming. *See* SANITATION, *p.* 636

Warp (*Carp., etc.*) To twist; applied to the twisting and distortion of timber, produced by shrinkage in drying, etc.

—— (*Eng., etc.*) To draw a heavy object along by means of a rope or cable which is coiled on a drum or windlass.

—— (*Lace Manufac.*) A beam or cylinder containing one system of the threads used in the manufacture of lace. *See* LACE MANUFACTURE.

—— (*Textile Manufac.*) The term applied to the series of spun threads, usually stronger and harder twisted than the weft, that run lengthwise of a piece of cloth in the loom. In the silk trade, the term "CANE" is synonymous with warp. *See also* WEAVER'S WARP.

——, **Backing** (*Textile Manufac.*) The method of putting a back to the cloth by using a separate warp.

——, **Centre** (*Textile Manufac.*) This may be either a stitching or a wadding warp. *See* WADDING.

——, **Stitching** (*Textile Manufac.*) A special warp for binding two fabrics together.

Warper's Brasses (*Lace Manufac.*) Rectangular plates of brass, generally ¼ in. by 2 in., with drilled holes, in number according to the purpose they have to serve. A series of them placed end to end form a sley for the production of the warp.

Warping (*Cotton Weaving*). Running together in some definite order a number of threads, from bobbins placed in a creel, so as to form a warp (*q.v.*) which may be prepared for the loom in a convenient form. The ends and length are determined beforehand. There are four distinct methods in Cotton Weaving: (1) Mill. (2) Sectional. (3) Beam. (4) Chain or lease.

—— (*Linen Manufac.*) Arranging the threads of yarn in lengths of one or more webs of cloth, so that they can be put on a beam for the loom. This is done either by winding from a few spools, round a cylindrical creel, till enough threads are put on; or a number of spools can be put on a flat frame and the threads run from these through a reed on to two or more beams. The former is called CHAIN WARPING, the latter BEAM WARPING.

—— (*Textile Manufac.*) An operation performed either by hand or machine. It consists of preparing the warp threads in the requisite order and length for the loom. *See* BEAM, CHAIN WARP, *and* LOOM.

Warping Mill (*Lace Manufac.*) An extended form of reel, such as that used for forming hanks or skeins of cotton, but much more strongly built. It may be 44 quarters, say 400 in. wide, and 3 or 4 yards in circumference. All the threads of the warp are arranged and wound upon this in correct order and length previous to being transferred to the warp beam.

Warp Machine (*Lace Manufac.*) A development of the hosiery or stocking machine. It makes fabric of the most diverse character, from heavy woollen cloth or blanket to the finest silk point net, according to the gauge of the machine. It may be adapted to make imitation crochet lace or lace curtains, its distinctive feature being the production of a looped or crochet stitch in contradistinction to twist-lace.

Warren Girder (*Civil Eng.*) A built-up or lattice girder, consisting of two horizontal members connected by bracing which forms a series of isosceles triangles. The sides of these triangles are alternately struts and ties, *i.e.* one is in compression, the next in tension, and so on.

Wash Dirt (*Mining*). Earthy matter, drift, etc., in which gold is found in alluvial deposits.

Washdown Closet *or* **"Short Hopper"** (*Sanitation*). Consists of a basin with an almost vertical back, so that the excrement falls directly into the water of the trap and not upon the sides of the basin. It should be supplied with a flushing rim, and the junction of the basin and trap, if not in one piece, should be so effected that the internal surface is perfectly smooth, thus obviating any collection of filth. It should be flushed with at least two gallons of water delivered by a 1¼-in. pipe from a water waste preventer fixed at a height of from 5 to 6 ft. to secure sufficient force thoroughly to wash out the basin.

Washer (*Eng., etc.*) A plate (usually in the form of a disc with a hole through the centre) which is slipped over the end of a bolt, and serves as a bed for the nut which is screwed down upon it. Washers are usually of iron, but leather, rubber, etc., are also used for special purposes, *e.g.* in cocks and valves to make watertight joints.

Washing (*Mining*). Separating superfluous matter (dirt, gangue, etc.) from ore by the action of water. The process usually depends upon the different densities of the materials acted upon, the heavy constituents remaining behind while the lighter ones are washed away.

Wash Leather. *See* CHAMOIS LEATHER.

Washout Closet (*Sanitation*). Consists of a basin so shaped that a certain amount of water is detained in it by means of a ridge over which the contents are carried into a siphon trap below. This form of closet requires a strong flush of water in order to carry away the excreta. Not now much in use, as it is not in accordance with the majority of by-laws.

Waste (*Print.*) The surplus sheets of a printed work or job.

—— (*Textile Manufac.*) This may be weavers', warpers', woollen, worsted, or mixed fibre. It is waste yarn that, after opening, is re-carded, and used as a substitute for wool.

Waste Pipe (*Build.*) The pipe that carries away the waste water from a bath, sink, etc.

Waste Preventer (*Plumb., etc.*) *See* WATER WASTE PREVENTER.

Waste Products and their Use. A complete list of waste products in industrial and commercial enterprises, as well as those of domestic origin, would occupy a great deal of space and cover a very large number of important and interesting manufacturing industries. The waste products of domestic origin are mainly of two kinds: (1) Animal refuse derived from the slaughter of animals used for food; (2) Town refuse collected from house to house.

Animal Refuse. Very little of the animal which is killed for human food is wasted. The HIDES are

sent to the tanner, who removes the hair and converts the skin into leather (*see* LEATHER MANUFACTURE), the hair being utilised afterwards as a binding material in the manufacture of plaster for the walls of houses. The larger BONES are used for the production of buttons, knife and tool handles, while the smaller bones are purchased by manure manufacturers, who grind and treat them with acid, to produce fertilising compounds, and a valuable oil is also obtained from these bones (*see* BONE OIL). The BLOOD, of which large quantities are produced in the slaughterhouse, is utilised for the preparation of albumen, or it can be treated for the manufacture of what is known as animal charcoal. From the HORNS of the animal are made combs, cigarette holders, buttons, and similar objects; even waste horn clippings can be utilised for this purpose. The feet of the animals are employed for the production of lubricating oils, such as neat's foot oil. The coarse FAT produces tallow and tallow oil. The INTESTINES are cleansed and converted into catgut, the finer qualities of which are used for violin strings. Another well-known preparation from this source is gold beater's skin. The BLADDERS are utilised for storing lard. The HAIR from various animals finds many uses, for example, the hair from rabbit skins is made into felt hats; the clippings from the hair dressers into wigs, curls, etc.; the skins, according to the animal from which they are obtained, find many uses, the rabbit furnishing trimmings for coats and other articles of apparel, while gloves are manufactured from goat skin, dog skin, and many other varieties of small hides. WOOLLEN WASTE.—The uses found for the waste from various industries which depend upon raw material derived from animals are interesting. Thus, in the case of worn-out woollen goods the material called shoddy' is obtained. Then the worn-out shoddy reappears in the form of druggets for the floor. From raw wool itself a useful oil or grease is obtained, which is familiar under the name of lanoline, and the various liquors resulting from the washing of wool yield by suitable treatment valuable potash salts. Wool and similar animal products, such as horn and blood, can be roasted for the production of yellow prussiate of potash. ARTIFICIAL MANURES are produced from all kinds of animal refuse, such as the offal from slaughterhouses, stale fish, sewerage matter, in fact from almost every kind of decaying animal refuse.

Town Refuse. This consists of a very miscellaneous collection of animal, vegetable, and mineral refuse. In some towns a systematic course of treatment is adopted, whereby any refuse which has a commercial value is sorted out from that which is of no value. The former is sold to merchants and manufacturers, while the latter is usually burnt. An average collection of this kind will yield saleable waste paper, rags, bottles, old tins (from which the tin can be recovered), broken glass, which can be used over again, and finally a mixture of cinders and combustible matter, which is of value to brick manufacturers. In other towns the whole of the collected refuse is burnt in large special destructors, the heat given out by the furnaces being sufficient to supply a large amount of heat energy for town purposes, such as the production of electricity for lighting. At Hastings the steam produced in this manner is used in pumping sea water for flushing the sewers and for watering the streets. The use found for the waste products of industrial enterprise, as distinct from domestic refuse, is a monument to the ingenuity and skill of the men engaged in manufacture.

Vegetable Refuse. The foremost instance is the utilisation of the by-products in the manufacture of coal gas. These are more fully treated under the heading of GAS MANUFACTURE (*q.v.*) Mention may be made of sal ammoniac, spirits of hartshorn, sulphate of ammonia, obtained from gas liquor; benzol, nitrobenzol, carbolic acid, aniline, anthracene from coal tar, the two latter compounds being the source of the well-known coal-tar dyes. The final refuse in the gas retorts is the well-known domestic coke. PAPERMAKING finds use for such materials as old rags, old waste paper, straw, old rope, canvas and sails, jute and hemp bagging, all of which are eventually converted into paper, cardboard, or papier-maché. Many of the by-products obtained during the manufacture of paper can be treated and used over again by means of ingenious chemical operations. In the STARCH INDUSTRY many apparently useless materials find profitable employment. In the manufacture of starch from wheat a sticky plastic substance called gluten is produced, which is employed in calico printing. The pulpy refuse is usually mixed with other materials and converted into cattle food. In the SOAP INDUSTRY the recovery of glycerine as a by-product is an interesting instance of the value of technical research. The treatment of fats with alkali for the manufacture of soap (*q.v.*) gives a large proportion of waste lyes from which glycerine is made. Glycerine is used in great quantities for the production of explosives, and industries having no apparent connection with one another are sometimes closely related. In the TIMBER TRADE much ingenuity has been displayed in the utilisation of waste wood. Large quantities of sawdust are mixed with tarry matter and converted into briquettes for fuel. Dried sawdust is used for polishing small metal goods, which are placed in closed vessels and rotated, the polishing being effected by the friction of the goods with the sawdust. Artificial wood is prepared from sawdust by the use of certain binding mediums like glue mixed with bichromate of potash. Wood waste is largely employed in the manufacture of oxalic acid, produced by fusing the wood waste with caustic soda, and this is largely used in textile industries. It may also be employed for the manufacture of crude acetic acid, the dry distillation of wood waste yielding wood spirit, acetic acid, and wood charcoal.

Mineral Refuse. One of the most remarkable instances of the recovery of valuable material from waste is the recovery of sulphur from ALKALI WASTE. According to the Alkali Inspector's twenty-third report for the year 1886, 387,000 tons of waste were produced at Widnes and Runcorn. This would contain about 58,000 tons of sulphur, nearly the whole of which was lost. In 1888 Mr. A. M. Chance introduced an improved process, by means of which this enormous weight of material could be treated with carbonic acid gas liberating sulphuretted hydrogen, which on burning with a sufficient quantity of air deposited the pure sulphur in a solid form. Not only was the waste material thus effectually dealt with, but naturally the cost of production of the soda and alkali was sensibly reduced. The introduction of chemical methods of washing the slimes and residues from GOLD MINES has resulted in very marked economies. Many of the slimes and residues though containing a very minute percentage of gold can be chemically treated by means of cyanide compounds (*see* GOLD, CYANIDES, and GAS MANU-

FACTURE [C]). The gold and silver residues obtained by photographers are carefully preserved and treated for the recovery of the precious metals. In IRON WORKS the slag produced is employed for useful purposes. The slag obtained from blast furnace works is converted into slag wool by means of a current of steam, and this is used as a composition for covering boilers and steam pipes. The slag is also made into building stone and hard brick; and when ground up fine in a mortar and mixed with cement forms a useful concreting material.

Waste Weir (*Civil Eng.*) A weir in a reservoir for discharging the superfluous water in time of flood.

Watch and Clock Making. Clocks and watches are machines automatically recording the number of vibrations made by a pendulum, or, by its substitute in portable timepieces, a balance and spring.

The machine contains (1) the MOTIVE POWER, usually a raised weight or coiled spring; (2) a TRAIN OF WHEELS and pinions moving with different velocities to record various required intervals of time; (3) the ESCAPEMENT, an arrangement for periodically arresting the advance of the train, so that the tendency of the motive force to accelerate the speed shall be checked at frequent and regular intervals, and for conveying to the pendulum or balance sufficient impulse to restore the energy lost in overcoming the various resistances tending to bring those time measurers to rest.

The mechanism of a good timepiece is so accurately made and so well designed that it does what perhaps no other machine of any kind is expected to do—that is, it will go night and day for years without skilled attention. The wheels and pinions usually have epicycloidal teeth, but in some parts of turret clocks, in the keyless mechanism of watches, and other parts where very low numbered pinions are not required, involute teeth may be advantageously used; either kind properly employed ensures smooth working, and, even more important, a constant angular velocity throughout the whole phase of contact of each tooth. The pinions and the escapement staffs are of highly polished tempered steel, to resist wear and reduce the effect of friction. The reduced portions, or pivots, which work in the bearings, are as small in diameter as the necessary strength will allow, and the bearings are often jewelled.

The mechanism of the finest timepiece is subject to one source of trouble, which will probably always be a trouble. It is necessary to lubricate nearly all the rubbing surfaces, and jewelled bearings do not remove this necessity. The lubricant must not be too thin or likely to evaporate, it must not be too thick or likely to corrode, and however good it may be there is always a possibility of one extreme in course of time; especially as an oil that will keep good for a long time with one wearer, will dry up with another, and will thicken with yet another. Except for the lubrication trouble, the timepiece, as a machine, may be accepted as a very good specimen of the perfection of mechanism. The natural errors to which the pendulum and the balance and spring are subject will be dealt with later.

The standard by which all timepieces are ultimately checked is the "Sidereal Day," the uniform interval of time taken by the earth to make one exact rotation on its axis; but the standard interval recorded by most clocks and watches is the "Mean Solar Day," an interval equal to the *average length* of the "Apparent Solar Day." No two consecutive solar days are of precisely equal duration, so the mean of these continually varying intervals is used as the standard for all civil purposes.

In checking the rate of a clock by astronomical observations with the aid of a transit or other meridian instrument, it will often be found convenient to use the transits of the sun. These occur at irregular intervals, but the irregularities are accurately known, and are furnished in the "Nautical Almanac" years in advance; we therefore find it just as reliable to use the sun, and for checking the rate of a mean-time clock the necessary calculations are easier than those required for sidereal observations.

Whole days are determined and checked by astronomical observations. The subdivisions of the day cannot be so determined. In modern timepieces the subdivisions are measured either by the oscillations of a pendulum or by the vibrations of a balance attached to an elastic spring.

The discovery of the isochronism of pendulum vibrations made it possible to subdivide the day with great accuracy. The time of vibration depends upon the length of the pendulum and is proportional to the square root of the length.

$$\tau = \pi\sqrt{\frac{l}{g}}$$

is the usual formula denoting the time of one complete swing in one direction; τ being the time in seconds, π the ratio of circumference to diameter, approximately 3·1416, l the length of the pendulum, and g the acceleration due to gravitation. "g" has different values at different parts of the earth's surface, but so long as the length of the pendulum does not alter, the time of vibration at any one place will be almost perfectly constant. A clock controlled by a pendulum is probably the most accurate of all timekeepers. The pendulum should not be shorter than a "seconds" pendulum = about 39·14 in. It, and the mechanism, should be rigidly supported, and a weight should be used to drive it, as the energy of impulse will then be sensibly constant. We find, however, that if the machine be mechanically perfect there are, at least, three sources of error to which the pendulum is liable—change in the amplitude of the arc described may cause a "circular error," change in the atmospheric pressure may cause a "barometric error," and change of temperature may cause a "temperature error."

If a pendulum is describing large arcs of vibration, and the arcs vary much in amplitude, there will be a circular error, as large arcs take *slightly* longer than small ones; but in clocks of precision the largest arc permitted is small, seldom more than 2° from the point of rest, and every effort is made to maintain the amplitude constant, so that the isochronism in a good clock is but little disturbed by the circular error.

The barometric error is due to changes in the atmospheric pressure: when the pressure increases, the pendulum meets with greater resistance to its progress and the clock loses. The error is small, estimated at about 1 second per day for a change of 3 inches in the barometric reading, but in very fine clocks some provision is made to counteract it. In the Greenwich sidereal clock a barometer tube is fitted inside the clock case; the rise and fall of the mercury in the open end of the tube cause a horseshoe magnet to recede from, or approach, two bar magnets fixed to the front and back of the pendulum bob, thus reinforcing the acceleration due to gravity,

more or less, according to the nearness together of the horseshoe and the pendulum magnets. The horseshoe is adjusted under the pendulum magnets with the unlike attracting poles opposite one another. For the new physical laboratory at Bushey House a clock has been made with an airtight case, an air pump is attached, the pressure will be reduced below the normal and maintained constant, so that no variation may arise from this cause.

The largest variation to which an ordinary pendulum is subject is due to the temperature error. Nearly all materials undergo changes of dimensions when the thermometer alters. An iron, or steel, or brass rod becomes longer in heat and goes slower, so that all good clocks require compensation pendulums. In all such pendulums two or more materials are used, having very different coefficients of expansion. The rod being of the material with a small expansion, the other parts are so arranged that just as much as the change in the rod tends to displace the centre of oscillation, the other part tends to move it in the opposite direction, and the effective length of the pendulum remains constant in all temperatures.

A mercurial pendulum has a rod of steel, and the bob is a jar of glass, or of steel, containing mercury. As mercury expands and contracts very much more than steel for the same change of temperature, we find that about 6 in. of mercury is sufficient to keep the centre of oscillation of a seconds pendulum at a constant distance from the suspension, and so compensate the temperature error.

A zinc and steel pendulum has a rod of steel; on the rating nut at the bottom rests a zinc tube, from the top of the zinc tube hangs a steel tube terminating in a collar on which the bob is supported *at its centre*, so that the expansion and contraction of the bob shall have little effect on the time. As the coefficient of expansion of zinc to that of steel is in about the proportion of 8 to 3, we find that a tube of zinc about 24 in. long is sufficient to compensate a seconds pendulum. The length of steel rod + the length of steel tube must be to the length of zinc tube *inversely* as the respective coefficients of expansion.

The recent experiments of Dr. Guillaume with alloys of nickel and steel, in different proportions, have produced some remarkable results. It is stated that at least one specimen has been produced having no expansion at all. There may be some doubt if so desirable a result can be repeated, but there is no doubt that many specimens of nickel steel have been obtained possessing exceedingly small coefficients. As with most alloys, the result of a melt is more or less uncertain; each individual rod should be tested, and a rather long process of annealing has to be undergone to make the metal workable, and to ensure its retaining its peculiar properties. Its use for pendulum rods is still in the experimental stage, but it promises to be a very valuable discovery for such a purpose, and as the clock at Bushey House, already referred to, has one of these rods for which a very short brass tube is sufficient to compensate it, the record of its performance will be looked forward to with great interest.

A pendulum cannot be used for a portable timekeeper, a BALANCE and SPRING taking its place in chronometers, watches, and carriage clocks. The balance is a flywheel, storing up the energy received at each impulse, thus being enabled in its return vibration to unlock the escapement, to allow the train of wheels and the hands to advance, and to receive fresh impulse. It is highly important that the balance shall be truly a "balance"—*i.e.*, that the staff on which it is mounted shall be accurately in the centre of the mass. If it be the least out of weight, or "out of poise," as it is called, the rate in the different vertical positions of the watch will vary; the balance will no longer be a "balance."

The regularity of the vibrations of a balance is due to the controlling influence of the spring. This is an elastic spring fixed at one end, the other end being attached to the balance near its axis. There is no circular error as with the pendulum. If the size and weight of the balance be suitably adapted to the energy of the motive power, and the spring is properly applied and adjusted, the arc of vibration may vary very much without any important change in the rate of vibration. If, owing to variation in the energy of impulse, the balance at one time travels twice as far as at another, it will travel twice as fast, and the time of vibration will be the same. The regularity of vibration is liable to disturbance by the varying effect of friction, and to the fact that the connection with the escapement has a greater retarding effect when the vibrations are small and the velocity slow, than when the arcs described are large and the speed of the balance rapid; but the modern timer is able to surmount these difficulties and obtains almost perfect isochronism. So much has been accomplished in this direction that the fusee, as a necessary equaliser of the motive power, has almost disappeared from the modern watch in favour of the going barrel, with its much simpler form of keyless mechanism.

The motion of the balance is affected, like that of the pendulum, by variation in the atmospheric pressure. Recent experiments indicate that the barometric error in a large watch is about 50 per cent. greater than the barometric error of a pendulum, that the error in a marine chronometer is a little less than that in a deck watch, while the error in small watches is slightly greater. There is at present no known method of correcting this, except by introducing centrifugal or isochronal errors, either of which might do more harm than good.

The time of vibration of a balance depends upon its "moment of inertia" (*q.v.*), and upon the elasticity and dimensions of the spring. As the elasticity of a spring of steel, and probably of any material suitable for balance springs, is very much affected by changes of temperature, we find that the temperature error of an uncompensated watch is far greater than that of a pendulum clock. When the temperature rises the diameter of the balance increases, its moment of inertia is greater, and this tends to make the watch lose. All the dimensions of the spring increase, it becomes longer, tending to make the watch lose, but in the same degree it becomes wider, tending to cause a gain; and for all changes of temperature the alterations in these two dimensions alone neutralise one another. It also becomes thicker, and this change of itself probably more than neutralises the increase in the diameter of the balance, so that the whole of the observed error is due to the change in the elastic nature of the spring.

The COMPENSATION BALANCE is designed to correct this error: it becomes smaller in heat, and larger in cold. In the ordinary form of compensation balance a steel disc is turned perfectly true. This is placed in a crucible containing molten brass. When cool the brass adheres, and is turned true, leaving a ring of brass outside the steel. The steel is recessed and cut away until only an inner ring of steel is left with a thin crossbar of the same piece of metal, in which the staff is fixed. A number of holes are drilled and

tapped through the bi-metallic ring; in these holes a less number of weights, usually gold screws, may be placed in different positions. The ring is cut right through in two opposite points, usually close to the crossbar, leaving each half of the ring fixed to the bar at one end, and quite free to move inwards or outwards at the other end. When the temperature rises the brass expands more than the steel, and the two metals, to remain together, must bend into a quicker curve, carrying the free ends of the rim in towards the centre. When the temperature falls the brass contracts more than the steel and flattens the curve, bringing the free ends outwards. How far the changes of curvature will affect the moment of inertia of the balance depends, in a great measure, upon how much of the movable weight is collected near the free ends of the rim. The final positions of the adjustable weights can only be determined by trial.

The thickness of the rim is dictated by experience. If too thick the weights are relatively light, their change of position has insufficient effect, and it may be necessary to substitute platinum screws for the gold ones at the free ends. If too thin there will be a centrifugal effect, greatest in the large arcs of vibration, tending to open the rims outwards, especially if much of the weight has to be collected near the free ends.

The proportion of brass to steel is an unsettled question. Some authorities have stated that they should be inversely as the respective modulus of elasticity. Others say inversely as the square roots of their elasticities. As the bending moment of an elastic bar of rectangular section is proportional to the *cube* of its thickness, it is possible that the thicknesses should be inversely as the cube roots of the respective elasticities. The two metals will then offer equal resistances to change of curvature.

The balance of a MARINE CHRONOMETER, instead of having gold screws round the rim as in watches, has two heavy brass weights grooved to fit the rim; these are held in position by pinching screws.

The compensation of a balance is not so perfect as that of a pendulum. With the latter it is only necessary that its length shall remain constant. The balance has to correct the errors due to changes in the elasticity of the spring, its effective radius must grow less in heat, and greater in cold. The change in the elasticity of the spring is, at least approximately, proportional to the change in the temperature; but the moment of inertia of the balance is proportional to the *square* of its radius of gyration, so that any balance changing its radius uniformly with the temperature is imperfectly compensated. It may be adjusted correctly for any two given temperatures, but the change in its moment of inertia will then cause it to gain at intermediate temperatures, and lose above or below the selected temperatures. In marine chronometers the error, which is never large, is in some cases reduced by adjusting the primary compensation for a narrower range of temperature than the total change it is to be adjusted for. The middle gain will then be less than if adjusted for a wider range. At the extremity of the selected range a supplementary or secondary compensation piece, called an "auxiliary," comes into action, and continues the compensation through a further limited change of temperature.

In NON-MAGNETISABLE WATCHES the balance spring, as well as the quick moving parts of the escapement, must be of other material than steel. The most successful of these springs are made of an alloy of palladium. For the lever, pallet, body, and roller aluminium bronze is one of the best materials.

T. D. W.

Water (*Chem.*) H_2O. A faintly blue coloured liquid, the blue colour only being apparent when a column of 2 metres or so is looked through; melts at 0° under a pressure of 1 atmosphere, or at 0·0076 under a pressure of water vapour equal to that of a column of mercury 4·66 mm. in height—that is, the melting point is raised or lowered by about 0·0075° for a decrease or increase respectively of 1 atmosphere pressure. Water is easily supercooled, so that if kept still and protected from dust it can be cooled far below its melting point without freezing; its vapour pressure at −10°, 0°, 15°, 100°, and 144° is respectively 2·1, 4·6, 12·7, 760, and 3040 in millimetres of mercury, from which it is seen that ice is markedly volatile and that water boils at 0°, 15°, 100°, or 144°, when the pressure is 4·6, 12·7, 760, and 3040 mm. of mercury respectively. When water freezes it increases in volume by about one-eleventh part, so that pipes and vessels containing water are often burst when water freezes in them. If the freezing is effected in a test tube immersed in a freezing mixture, the water is seen to crystallise in slender needles, but in snow the small crystals are united to one another, forming very beautiful six-sided geometrical figures—snow crystals. The latent heat of fusion of ice is 79 calories per gram; the latent heat of evaporation of water at 100° is 536 calories per gram. At 4° 1 cc. of water weighs 1 gram; this is the definition of the gram, the temperature of 4° being selected because water was believed to have its maximum density at this temperature. The real point of maximum density of water is 3·945°, that is, whether water is cooled below or heated above this temperature it expands: for example, 1 c.c. of water at 4° becomes 1·000122 c.c. at 0°, 1·000118 c.c. at 8°, 1·000997 c.c. at 16°. The specific heat of water at 15° is unity; it varies with the temperature. The refractive index for the D line is 1·3335 at 18°; it varies with the temperature. Water is a bad conductor of heat and electricity; for heat its conductivity is 0·00154 ($cm.^2/sec.$); for electricity it is $0{\cdot}04 \times 10^{-10}$ reciprocal ohm centimetres and referred to mercury as unit at 18° in the case of the purest water ever obtained; while for absolutely pure water it would probably be $0{\cdot}036 \times 10^{-10}$. (See below.) The conductivity for electricity increases with the temperature. The vapour of water has a density corresponding to the formula H_2O; but in the liquid state the molecules are almost certainly associated. An association of simple molecules of water to form more complex molecules would explain a number of the peculiar thermal properties of water; thus it has been assumed that water at 0° contains the two kinds of molecules $(H_2O)_3$ and $(H_2O)_2$—trihydrol and dihydrol. The high latent heat of fusion of ice, and its high specific heat, are probably due to the circumstance that much heat is required to resolve the trihydrol molecules into the simpler dihydrol molecules, while the high latent heat of evaporation may be due to the circumstance that a further large amount of heat is required to change the dihydrol molecules into single molecules, for steam consists, as its vapour density shows, of single molecules. Now Ramsay and Shields have shown, from the molecular surface energy of water, that at 5° water has a molecular weight of between 3×18 and 4×18. Water is resolved into its elements when heated to a high temperature; dis-

sociation begins at about 950° and is complete at something over 2500°; it is also decomposed when electric sparks are passed through its vapour. Chemically, water is at the same time a weak acid and a weak base; this is shown by adding water to some water containing phenol phthalein rendered pink by a drop of dilute caustic soda solution, when the colour will be removed, and by adding water to some water containing methyl orange rendered pink by a drop of dilute sulphuric acid, when the colour will be changed to yellow. From the electrical conductivity of pure water it has been calculated that 1,000,000 litres at 18° contain 0·08 gram hydrogen and 1·33 gram hydroxyl ions; yet small as the amount of ionisation is it corresponds to some millions of hydrogen ions in each cubic millimetre of water. This ionisation of water enables us to explain the behaviour of (1) salts formed by the union of a weak base with a strong acid, (2) salts formed by the union of a strong base with a weak acid in dilute aqueous solution. For example, (1) a solution of ferric chloride has an acid reaction and at great dilution ceases to show the ordinary reactions of the ferric ion; but if some hydrochloric acid is added to the liquid, it will again show the reactions for the ferric ion—

$$\overset{3+}{Fe} + 3\overset{-}{Cl} + 3\overset{+}{H} + 3\overset{-}{OH} = \underbrace{Fe(OH)_3}_{\text{Colloidal ferric hydroxide.}} + 3\overset{-}{Cl} + 3\overset{+}{H}$$

—excess of hydrochloric acid reconverts the hydroxide into chloride. (2) Potassium cyanide solutions are alkaline and smell of prussic acid.

$$\overset{+}{K} + \overset{-}{CN} + \overset{+}{H} + \overset{-}{OH} = \overset{+}{K} + \overset{-}{OH} + HCN$$

The presence of water often causes reactions to occur which will not occur in its absence, as the burning of phosphorus in oxygen, the union of hydrogen and oxygen or chlorine, the dissociation of ammonium and mercurous chlorides, and others. Many metals decompose water: sodium, potassium, calcium, barium at the ordinary temperature; iron, zinc, magnesium only on heating; in all these cases hydrogen is liberated and the hydroxide of the metal formed, or if the hydroxide is not stable at a high temperature the oxide is formed. The halogens decompose water, the speed of the decomposition decreasing with the atomic weight of the halogen. For the action of carbon *see* WATER GAS. Water reacts with basic oxides to form alkaline hydroxides, and with many non-metallic oxides and the highest oxides of some metals to form acid hydroxides (acids). It also unites with many salts, as what is called water of crystallisation, thus $CaCl_2 6H_2O$, $CuSO_4 5H_2O$, $FeSO_4 7H_2O$, $K_4Fe(CN)_6 3H_2O$, and a vast number more. The last three whose formulæ are given are coloured blue, green, and yellow respectively, but the anhydrous salts are all white; so that some coloured salts owe their colour to their water of crystallisation. It is worthy of note that many salts which crystallise with water of crystallisation have in this state a volume equal to that of the water they contain when in the form of ice—*e.g.* the gram molecule, $Na_2CO_3 10H_2O$, has the same volume as $10H_2O$ in the form of ice. *See also* WERNER'S THEORY. For the behaviour of water as a solvent, *see* SOLUTIONS. Water is produced when hydrogen burns in oxygen or air; in this reaction hydrogen peroxide is first formed, either wholly or in part, and this is decomposed at the high temperature into water and oxygen. The production of hydrogen peroxide is shown by directing the flame of hydrogen burning in air against ice, and testing the melted ice for the peroxide. Water is also formed when compounds of hydrogen burn in air or oxygen—*e.g.* when ammonia burns in oxygen, and coal gas in air; it is also formed when an acid acts on an oxide, hydroxide, or carbonate. In the formation of water from its elements much heat is evolved; the production of 18 grams of water at 18° from its elements evolves 67·9 large calories (1 large calorie = 1000 small calories). When hydrogen and oxygen are mixed in the right proportions to form water, and a light applied, the union is very rapid (in *long* tubes it occurs at about the speed of sound), and it is this sudden evolution of a large amount of heat that is responsible for the explosion which occurs. The composition of water by weight has been determined in several ways. Professor Morley proceeded as follows: ". . . A quantity of hydrogen was weighed while absorbed in palladium, a quantity of oxygen was weighed in a globe, the two were combined, and the water produced was weighed. The two gases were brought together at two platinum jets enclosed in a small glass apparatus, which was weighed while exhausted, where they were made to combine. When the combustion was ended, the gas remaining in this combustion apparatus and the connecting tubes was extracted with a Töpler air pump, measured and analysed. The combustion tube, the globe which had contained oxygen, and the palladium tube were weighed again. From the amounts of oxygen and hydrogen extracted were subtracted the amounts of the gases found in the analysis; the remainders were the quantities combined in the combustion apparatus. . . . The amount of water produced was measured by the gain in weight of the combustion apparatus. . . . The volume of hydrogen used in most of the experiments was forty-two or forty-three litres; the amount of water produced was about thirty-four grammes in each experiment; twelve successful experiments were made. The amount of gas left unburned, and therefore measured in the endiometer, varied from a six-hundredth to a ten-thousandth of the quantity concerned." The mean result is 2 parts by weight of hydrogen to 15·879 parts by weight of oxygen. The determination of the composition of water by volume has been made by exploding large quantities of oxygen and hydrogen in small known quantities at a time, and determining the composition of the residue at the end. At 15° one volume of oxygen unites with 2·00245 volumes of hydrogen (Scott).

Natural waters are never pure. When pure water is required in the laboratory, ordinary tap water is distilled. Water which has been distilled from tap water is pure enough for most purposes, but if required quite free from ammonia and organic matter and minute traces of substances carried over by spirting, special measures must be taken. To get water free from ammonia, some potassium hydrogen sulphate may be added to the water before distilling; to get it free from organic matter and ammonia, the water must be boiled for some hours, in a flask provided with a reflux condenser, with potassium permanganate and caustic potash, then distilled. The first portions of the distillate will contain ammonia, but the succeeding portions will be free. The distillation must not be continued too far, or contamination from spirting results. Very pure water can be obtained by the apparatus shown in the figures. Fig. 1 shows the complete apparatus. Fig. 2 shows the still,

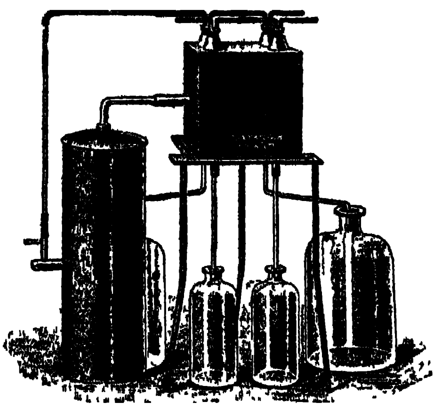


FIG. 1.

which is provided with a constant level arrangement B, F, an opening for cleaning, A, baffle plates starting at D to prevent spirting, and a cover, E, to prevent loss of heat; the arrows show the direction taken by the steam. Fig. 3 shows the condensing arrangement, which is a copper box, into the top of which four glass tubes are let, each provided with inlet and delivery tubes for condensing water; below each tube is a funnel-shaped tube which collects the water and delivers it into a bottle placed below, the side tube brings in the steam; tube 5 carries away the water which condenses on the metal of the condenser. A rapid stream of cold water passes through tubes 1 and 2, a slow stream through 3 and 4—this also feeds the still. Tubes 1 and 2 give the best water, and tube 5 gives the worst. Water having a conductivity of one reciprocal megohm can be obtained from tubes 1 and 2 by adding a little potassium hydrogen sulphate to the water in the still, and by boiling this water in a platinum vessel its conductivity is reduced by half, when it has a conductivity ten times that given above for the purest

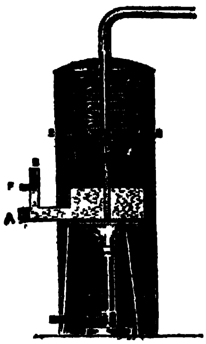


FIG. 2.

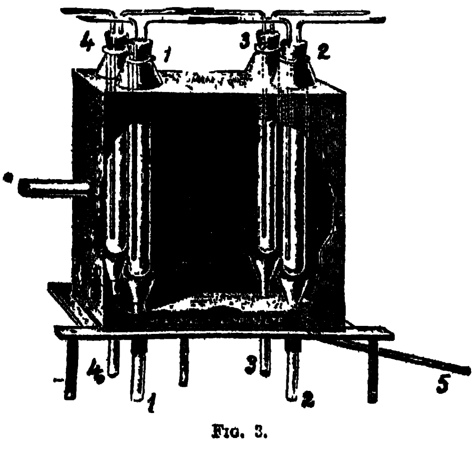


FIG. 3.

water yet obtained. This purest water was obtained by Kohlrausch and Heydweiler, who distilled water in a glass vessel under a pressure of 0·01 mm. mercury; the glass vessel employed had been in constant use for ten years, so that the soluble portions of the glass had been practically all removed (they say they only obtained the above result with one out of a series of vessels which they used). In such water the impurity is about 1 part in 100,000,000 parts, or about 10,000 times less than the weight of the gases the water could absorb from the atmosphere.

On the large scale, for drinking purposes, water is purified by filtration (*q.v.*) *See also* SANITATION. Of the ordinary natural waters, rain water is the purest, and contains on an average about 2 to 3 parts of dissolved solids in 100,000. It contains the gases which it has washed out of the atmosphere, and traces of solids such as common salt. In towns it invariably contains sulphuric acid, and products from the incomplete combustion of coal. Spring and river waters owe their impurities to the ground through which they have passed; thus an average spring or river water will contain about 30 parts of dissolved solids in 100,000. Many spring waters have medicinal properties, for example, those at Harrogate (sulphur wells), which contains sulphuretted hydrogen, and magnesium sulphate and chloride; at Woodhall, which contains sodium bromide and iodide, and much carbonic acid; at Homburg, which contains bicarbonate of iron, lithium chloride, sodium bromide and traces of iodide, and much common salt and magnesium chloride; at Vichy, which contains very large quantities of the bicarbonates of sodium, calcium, and magnesium; at Hunyádi János, which contains very large quantities of magnesium and sodium sulphates. Sea water contains about 3,900 parts of dissolved solids in 100,000 parts. The solids consist of the chlorides, sulphates, bromides, iodides of sodium, magnesium, potassium, calcium, and lithium, the iodine and lithium being present in minute amount only. Waters used for washing purposes are classified as hard and soft. These terms relate to the action of the water on soap; a water which yields a lather with difficulty is called hard. To explain the action of a hard water on soap, we shall suppose that soap is sodium stearate, $NaC_{18}H_{35}O_2$. Soluble salts of calcium and magnesium act on soap thus:

$$CaSO_4 + 2NaC_{18}H_{35}O_2 = \underbrace{Ca(C_{18}H_{35}O_2)_2}_{\text{Calcium stearate.}} + Na_2SO_4$$

Now calcium and magnesium stearates being insoluble in water, separate as solids, and this goes on until all the calcium and magnesium salts present in the water are removed as calcium and magnesium stearates, after which the soap begins to dissolve in the water and produces a lather. Thus the harder the water is, the more soap will it require before a lather can be formed. The four salts which commonly cause water to be hard are the acid carbonates and the sulphates of calcium and magnesium. When water containing the acid carbonates of these metals in solution is either boiled or treated with milk of lime (*see* CALCIUM COMPOUNDS), they are converted into the normal carbonates, which are nearly insoluble in water:

$$Ca(HCO_3)_2 = CaCO_3 + H_2O + CO_2$$
$$Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O.$$

That is, the hardness due to the acid carbonates is removed; this kind of hardness is therefore called Temporary Hardness. The sulphates of calcium and magnesium cannot be removed by boiling, and lime

water has no action on calcium sulphate, while it would only replace magnesium sulphate by its equivalent of calcium sulphate. The hardness due to the sulphates (and chlorides if present) of these metals is therefore called Permanent Hardness. Both temporary and permanent hardness can be nearly completely removed by the addition of both milk of lime and caustic soda in proportions determined on after analysis:

$$Ca(HCO_3)_2 + CaSO_4 + 2NaOH = 2CaCO_3 + Na_2SO_4 + 2H_2O,$$

excess of acid calcium carbonate being removed by the milk of lime. Natural waters such as spring, well, and river water are often contaminated by drainage from cultivated land and by the addition of sewage. Such waters contain organic matter and the products of its decomposition, such as ammonia, nitrites, nitrates, and sodium chloride (from urine). The ammonia in such water is estimated by making it alkaline, distilling over the ammonia, and comparing the colour given to the distillate on adding Nessler's Reagent, with that produced by the same reagent in known amounts of ammonia. An idea of the organic matter can be obtained by distilling the residue from the last distillation with alkaline potassium permanganate, when a portion of the organic nitrogen is converted into ammonia, which distils over and is estimated as before; also the water is treated with potassium permanganate and sulphuric acid, when the organic matter is oxidised—in an analysis these last two results are returned as albuminoid ammonia and oxygen absorbed respectively. The nitrites are estimated by the depth of colour they produce in an acidified solution of meta-phenylene diamine (*see* BISMARCK BROWN); and the nitrates are reduced to ammonia by a zinc-copper couple and the ammonia is distilled over and estimated as before—the nitrites and nitrates are returned as nitrogen. A water for drinking purposes should not contain in 100,000 parts over ·005 parts ammonia, ·01 parts albuminoid ammonia, ·1 part oxygen absorbed in one hour, about ·2 parts of nitrate expressed as nitrogen, 2 parts of total chlorine; it should contain no nitrite. But these numbers are all subject to allowances for the source of the water. A drinking water should always be examined bacteriologically as well as chemically.

W. H. H.

Water Bar (*Build.*) A longitudinal bar of metal let into a groove between the wood and stone sills of a window to prevent water from penetrating the joint.

Water Battery (*Elect.*) A series of simple cells having copper and zinc plates immersed in water. It is chiefly useful in the calibration of electrometers.

Water Colour Painting. *See* PAINTING.

Water Cooled. A term applied to machinery or apparatus which is surrounded by a space in or through which water flows, to carry off heat and so prevent undue rise of temperature. The cylinder of a gas engine, etc., is commonly water cooled. *See* PETROL ENGINE, *p.* 514.

Watered Tabby (*Silk Manufac.*) Plain silk woven as tabby (*q.v.*) a coarse weft being used. The watered effect is obtained by pressure between rollers.

Water Gas (*Chem.*) A mixture of hydrogen (about 50 per cent.), carbon monoxide (about 40 per cent.), carbon dioxide (about 3 per cent.), methane (about 0·5 per cent.), nitrogen (about 4 per cent.), and traces of other gases, especially sulphuretted hydrogen, the mixture being produced by blowing steam over fuel such as coke heated to a sufficiently high temperature. Many forms of apparatus are in use for the manufacture of water gas, particularly in the United States of America, where it is used on an enormous scale. The method of working is as follows:—Air is drawn over burning coal or coke by an exhausting pump, the gas from the burning fuel is led over brickwork, which is thereby heated to a high temperature, and it may then be used to heat a boiler: this gas is producer gas, and is combustible, but has not the same value as water gas as a calorific agent; it is utilised if possible. When the brickwork and fuel are hot enough, steam is blown through the heated brickwork and then over the fuel; the gas so produced is water gas, and it is sent to gas holders. The reaction between the steam and coal is strongly endothermic, so that the temperature of the fuel falls: when it has fallen low enough air is drawn over the fuel again, and so on. The principal reactions are

$$C + H_2O = CO + H_2$$
$$C + 2H_2O = CO_2 + 2H_2.$$

The former absorbs 27,700 small calories, the latter 17,160. At 1,000° the former reaction occurs almost to the exclusion of the latter, but at 600° the reverse is the case; but even at the higher temperature excess of steam must not be used, or it will react with the carbon monoxide, forming the dioxide and hydrogen.

Water gas burns with a blue flame; it requires about half as much air for its combustion as coal gas does: its "calorific power" is about half that of coal gas: in British Thermal Units it amounts to about 300. ("Calorific power"=the number of British Thermal Units evolved by the combustion of 1 cubic foot of the gas. The B.T.U. is the heat required to raise 1 pound of water from 60° F. to 61° F. =252 calories). Water gas is extremely poisonous on account of its large percentage of carbon monoxide and as the gas has practically no smell the use of the pure gas is not free from danger. In 1889 two workmen employed at the Leeds Forge Works were poisoned by the gas in a cabin—a cooking stove supplied by the gas had been turned on and not lighted; and two days afterwards several medical men performing the post-mortem in a room containing some gas burners partly turned on but unlighted, experienced symptoms of carbon-monoxide poisoning.

Water gas having no illuminating power can only be used for heating purposes, or with a Welsbach or similar mantle for illuminating purposes. When required to be used for lighting as well as for heating purposes it is "carburetted"—that is, mixed with oil gas and heated to a high temperature, whereby hydrocarbons that burn with a luminous flame are added to the gas. W. H. H.

To enable an escape of the gas to be easily detected, a small quantity of a vapour having a pronounced smell is sometimes added to it—a trace of carbon disulphide serves the purpose.

Water Glass (*Chem.*) *See* SOLUBLE GLASS *and* SODIUM COMPOUNDS.

Water Glass Painting. *See* PAINTING.

Water Joint (*Build.*) A device used in jointing stone cornices, etc. A ridge is formed on each side of the joint on the top surface, to throw off the rain and prevent it getting into the joint.

Water Lock. A WATER SEAL (*q.v.*).

Watermark (*Paper Manufac.*) The transparent name or pattern produced in paper by the "dandy roll" or other means.

Water Meters. There are two principal kinds of water meter, the most accurate type being the POSITIVE METER, in which the whole of the water supplied passes through a cylinder fitted with a piston whose movements are recorded by suitable mechanism. For large supplies a TURBINE METER is used, in which a small water turbine (*q.v.*) is driven by the current of water, and the revolutions of the turbine recorded by mechanism. From this the amount of water which has flowed through the meter may be found.

Waterproof (*Woollen or Worsted Manufac.*) A cloth which has been chemically treated to make it impervious to wet. *See also under* RUBBER.

Waterproof Paper. The Willesden paper consists of ordinary paper passed through a bath of cupro-ammonium (a solution of copper in ammonia).

Water Seal (*Plumb*). *See* SEAL *and* SANITATION (SEWERAGE AND DRAINAGE), *p.* 638.

Waterspout (*Meteorol*). Cloud brought down to the land or water surface by a rapid gyrating motion like that which takes place near the centre of a tornado. When occurring over a water surface, the level of this surface is slightly raised.

Water Supply. *See* SANITATION, *p.* 636.

Water Twist (*Cotton Manufac.*) A noted strong, round and uniform yarn, spun on the flyer or throstle frame. Originally spun on Arkwright's water frame.

Water Waste Preventer (*Sanitation*). A flushing apparatus which serves to break the connection between the water supply pipe and the water closet. The most ordinary forms in use are the "valve cistern" and the "siphon waste preventer." In the former water only flows so long as the chain is held. It is open to objection, as the cistern is liable not to to be completely emptied. In the siphon waste preventer one pull of the chain is sufficient to put the siphon in action and discharge the entire contents of the cistern. Water waste preventers should be fixed at a height of not less than 4 feet above the basin in order to secure a proper flush, and should contain not less than 2 gallons of water, the service pipe being 1¼ or 1½ inches in diameter.

Water Way (*Plumb.*) The aperture through a cock or valve when open.

Watt (*Elect.*) The unit of power in ordinary electrical practice. It is the energy furnished in 1 second by a current of 1 ampère flowing under a potential difference of 1 volt—*i.e.* 1 JOULE (*q.v.*)—per second. One horse power (*q.v.*) equals 746 watts.

Watt Hour (*Elect. Eng.*) A unit of supply of electrical energy, being a supply of 1 watt for 1 hour. The commercial unit is 1,000 watt hours, and is known as 1 Board of Trade Unit (1 B.T.U.)

Wattless Current (*Elect.*) The number of watts supplied by an alternating current whose virtual value is $\bar{C}$, virtual voltage $\bar{E}$, and angle of lag ϕ, is $\bar{C}\bar{E} \cos \phi$. If the current be regarded as resolved into two components, one being $\bar{C} \cos \phi$ which is in phase with the volts, and may be termed the WORKING CURRENT, and the other $\bar{C} \sin \phi$, which differs in phase from the volts by 90°, and contributes nothing to the watts, then this second component is the WATTLESS CURRENT.

Wattmeter (*Elect. Eng.*) An instrument for measuring the power supplied to any electric circuit; in direct current circuits this is the simple product of the current in ampères, by the voltage. For alternating current circuits it is $\bar{C}\bar{E} \cos \phi$, where $\bar{C}$ and $\bar{E}$ are the virtual current and virtual voltage, and ϕ the angle of lag.

Watt's Indicator and Indicator Diagram (*Eng.*) *See* INDICATOR, etc.

Wavellite (*Min.*) Hydrous phosphate of alumina; orthorhombic, usually in small spheres having a radial structure; nearly perfect cleavage; colour white to brownish. Found in Devon and Cornwall, Scotland, Ireland, Central Europe, United States.

Wave Moulding (*Architect*). A moulding very freely used in decorated Gothic work. It consists of two ogee (*q.v.*) mouldings, forming a hollow with a swelling in the centre.

Waves and Wave Motion (*Phys.*) A wave is a periodic disturbance which is passed on continuously from one part of a medium to the next. The disturbance or motion of the individual particles of the medium may take different forms. In water waves, in a vibrating string, and in light waves, it is at right angles to the direction of propagation of the wave; such disturbances are termed TRANSVERSE WAVES. In the transmission of sound through air, the disturbance occurs in the same direction as the propagation: the disturbances are termed LONGITUDINAL WAVES. The velocity of a wave is the rate at which the disturbance travels. Generally speaking, if E be the elasticity of the medium, and ρ its density, the velocity V is—

$$\sqrt{\frac{E}{\rho}}$$

Here E is the particular modulus of elasticity concerned in the propagation. For a sound wave in a gas it is the volume elasticity, for a longitudinal wave in a solid rod it is Young's modulus, and for a torsional wave it is the simple rigidity. For a cord or string whose mass per unit length is m, and which is stretched with a tension T, the velocity of a transverse impulse is—

$$V = \sqrt{\frac{T}{m}}$$

The WAVE LENGTH is the distance from any given particle in the medium, to the next particle whose displacement and motion are similar. In water waves, for example, it is the distance from crest to crest, or hollow to hollow. If n be the frequency of the waves, *i.e.* the number which are produced, or which pass a given point, in unit time, and if V be the velocity and λ the wave length, then $V = n\lambda$.

A WAVE FRONT is a surface (or line) drawn through particles of the medium which are in the same phase of vibration. If the waves be in two dimensions, as in the case of water waves, the surface becomes a line; thus if a stone be dropped into still water, the waves travel outward from the point of disturbance, and the wave fronts are circles, made readily visible by the successive crests and troughs. Waves may be described according to the geometrical form of the wave front; *e.g.* a SPHERICAL WAVE, such as travels through free air from a sounding body, a PLANE WAVE, etc.

A line coinciding with the direction of propagation

of the disturbance is termed a RAY. In the case mentioned, the rays are actual radii of the circles, and obviously at right angles to the wave front.

Waves, Electric (*Phys.*) When an oscillatory discharge (*q.v.*) occurs, a portion of the energy is given off from the circuit and sets up in the surrounding medium the form of radiation known as Electric Waves, which closely resemble light and heat waves in their physical properties. *See* RADIATION, *p.* 591.

Electric waves are usually produced by the passage of a spark between two polished metal balls, which are charged up to a high difference of potential by means of an induction coil. The frequency of the waves is the same as that of the oscillatory discharge, and therefore varies according to the self-induction, resistance, and capacity of the circuit in which the discharge occurs. Waves so produced are detected in several ways, of which the most important are the RESONATOR and the COHERER. The Resonator consists of a simple circuit, usually of thick wire carrying metal balls at its ends, which are bent round till they nearly meet, and so form a narrow spark gap. If the resonator be correctly "tuned" or adjusted in size, the presence of electric waves can be detected by sparks produced between the metal balls. The Coherer consists of a small tube containing metal filings, included in series with a galvanometer and a cell, or with a delicate relay actuating ordinary telegraphic instruments. The normal resistance of the filings is so great that no appreciable current flows in the circuit, but directly electric waves impinge on the coherer it becomes a conductor, and a current flows through the galvanometer, producing a readable deflection. If the coherer be now tapped lightly it returns to its former condition, and the current stops.

Electric waves can be reflected by plane or curved mirrors, and brought to a focus by the latter. They can be refracted (Hertz used prisms made of pitch for this purpose), and they can be polarised. Measurements can be made of their wave length and their velocity, which latter is found to correspond very closely with that of light.

Wave Theory (*Phys.*) The theory which explains the phenomena of light and other forms of radiant energy by the formation of waves through an invisible medium, the ETHER, which fills all space. The WAVE *or* UNDULATORY THEORY superseded the earlier CORPUSCULAR *or* EMISSION THEORY, (which assumed that a luminous body emitted small particles which travelled through space at a high velocity), and furnishes an explanation of all known phenomena of the nature of light.

Wavy (*Her.*) A bar, bend, or other ordinary (*q.v.*) may be represented "wavy" or curved with three undulations. Wavy or undée is also one of the forms of partition lines. *See* HERALDRY.

Wavy Rule (*Typog.*) Brass rule, the face of which is in the form of waves.

Wax (*Chem.*). A name given to many substances, of animal and vegetable origin, of very different chemical composition, but possessing some of the physical properties of beeswax. A true wax contains one or more of the following classes of compounds: (1) An ester composed of a higher fatty acid and a higher fatty alcohol; (2) An ester composed of a higher fatty acid and glycerine; (3) A free fatty acid. Of these (1) must be a constituent.

Wax.	*Ester* (1).	*Ester* (2).	*Fatty acid* (3).
Beeswax.	Myricyl palmitate (*See* PALMITIC ACID) Ceryl cerotate.	—	Cerotic acid
Chinese wax	Ceryl cerotate. (*See* CERYL ALCOHOL)	—	—
Japan wax	—	Glyceryl palmitate	Palmitic acid
Spermaceti	Cetyl palmitate	—	—

Paraffin wax is on the above definition not a wax at all; it is a mixture of the higher solid hydrocarbon of the paraffin series. *See also* BEESWAX: SPERMACETI.

Waxed Leather (*Leather Manufac.*) Leather finished flesh side outwards. The leather is coated with a size or waxing solution made of oil, lampblack, and gelatine. Sometimes small quantities of various waxes are used to give a good polished appearance.

Way Leave, Way Lease. Permission obtained from the owner for the carrying of a pipe, wire, etc., across any property.

Ways (*Eng.*) (1) Longitudinal guides for a table which supports and advances work in the direction of the operating tool. (2) The massive timbers along which a ship slides into the water when being launched.

Wealden Rocks (*Geol.*) The lowest division of the Cretaceous system, resting on the Jurassic Rocks. *See* STRATA, TABLE OF (Appendix).

Weather (*Meteorol.*) The atmospheric conditions that prevail at any particular moment or during a short period of time as shown by the meteorological elements. *See* METEOROLOGY.

Weather Boarding (*Carp. and Join.*) Feather-edged boards fixed horizontally, the thick edge of one board overlapping the thin edge of the next. Used on roofs and walls of wooden buildings.

Weathering (*Build.*) Forming a sloping surface on sills, etc., in order to throw off rain water.

—— (*Geol.*) The process of decomposition which occurs in the superficial layers of rocks where they are exposed to atmospheric influences.

Weather Lore (*Meteorol.*) Sayings relating to weather based on observations of weather sequences and noting the foreshadowed effects of certain atmospheric conditions on objects animate and inanimate.

Weather Maps (*Meteorol.*) Charts which show the prevailing atmospheric conditions at any particular moment of time.

Weather Moulding (*Architect.*) *See* HOOD MOULD.

Weaver's Warp *or* **Web** (*Textiles*) A warp containing a number of ends placed side by side and wound or coiled in laps on a beam ready for the loom.

Weaving. *See* LOOM, COTTON, LINEN, SILK, WOOL.

Weaving Plan (*Weaving*). A plan showing the working design on the least number of healds, shafts, and picks possible. From this the tappets are set, or dobby lattices are pegged, so as to produce the correct pattern in cloth. Other terms are: tappet plan, lifting plan, pegging plan, tie up.

Web (*Eng., Build., etc.*) The central vertical part between the flanges of a girder.

Web (*Paper Manufac.*) The term usually applied to the sheet of paper as it comes wet from the machine wire.

—— (*Weaving*). (1) The warp in a loom. (2) The whole piece cloth woven in the loom. (3) A piece of linen cloth of specific size.

Weber (*Elect.*) An old term for the AMPÈRE (*q.v.*)

Web Glass (*Textiles*). A glass used for counting the number of threads in a given space of the cloth to find the set or fineness. 37″, 38″, and 40″ are the glasses most commonly used in Ireland. These are respectively the 200th part of 37, 38, and 40 inches as the set of the cloth is so many 200 threads in 40″ in the red, or 38″ of brown cloth, or 37″ of white cloth, or something near to this. *See* SET.

Web Machine (*Print.*) A printing machine on which the sheets are carried forward to the impression cylinder by means of tapes.

Websterite (*Min.*) A hydrous sulphate of alumina, $Al_2SO_6 . 9H_2O$; occurs in earthy white masses in Kent, Sussex, and elsewhere, usually in the chalk "pipes."

Wedge Photometer (*Astron.*) *See* PHOTOMETER.

Wedgwood Ware. Josiah Wedgwood (1730—1795) commenced business on his own account in 1759. He took Thomas Bentley into partnership in 1768. His manufactory at Etruria, Staffordshire, was opened in 1769. The name of Wedgwood will ever remain associated with some of the finest keramic productions of the eighteenth century. The Jasper Cameo wares, the black basalt statuettes, and the models by Flaxman, as well as the classical forms, are of the greatest beauty.

Weft, Woof, or Shoot (*Textile Manufac.*) The yarn or thread added to the warp in weaving by means of the shuttle passing to and fro from selvedge to selvedge. Also termed "abb" in the West of England, and "filling" in America. It is usually spun softer than the warp yarn, being twisted less. "Cop" weft (*q.v.*) is generally twisted in the opposite direction to warp (*q.v.*)

Weft, Backing (*Textile Manufac.*) Special yarn, usually thicker in counts than that used for the face weft, and confined to the back of the cloth in weaving, for giving weight and substance.

Weft Fork (*Textile Manufac.*) A simple and ingenious contrivance for stopping a loom automatically should the weft in shuttle break or become exhausted.

Weighting (*Textile Manufac.*) The variable amount of tension required to be applied to beams or warp to keep the warp yarns in proper position on the loom: or in lace manufacture to obtain various effects. *See* LOOM.

Weights and Measures. The English standards of weights and measures are derived from certain arbitrary standards preserved by the Board of Trade. The chief of these are the YARD, which is legally defined as the distance between two marks on a standard metal bar, measured at 62° F., and the POUND, of which the standard is the mass of a certain piece of platinum. Duplicates of these standards, which have been accurately compared with the originals, are also preserved in various places.

I. ENGLISH MEASURES.

(1) *Length* (Linear Measure).

12 inches (*ins.*) = 1 foot (*ft.*)
3 feet = 1 yard (*yd.*)
5½ yards = 1 rod, pole, or perch.
40 poles (220 yards) = 1 furlong.
8 furlongs = 1760 yards = 1 mile.
1 geographical mile = 6082·66 feet.
1 nautical mile = 6080 feet.
3 miles = 1 league.

Surveyors use the following:

1 chain = 100 links = 22 yards.

Electricians use a unit termed a mil.

1 mil = ·001 inch.

Miners and sailors use the fathom = 6 feet (*approximately*).

(A cable = 100 fathoms, 10 cables = 1 geographical mile.)

(2) *Area* (Square Measure).

144 square inches = 1 square foot.
9 square feet = 1 square yard.
30¼ yards = 1 square rod, pole, or perch.
40 square rods = 1 rood.
640 acres (3,097,600 square yards) = 1 square mile.

Surveyors use:

484 square yards = 1 square chain.
10 square chains = 1 acre.

(3) *Volume* (Cubic Measure).

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.
4 gills = 1 pint.
2 pints = 1 quart.
4 quarts = 1 gallon = ·16057 cubic feet.
2 gallons = 1 peck.
4 pecks = 1 bushel.
8 bushels = 1 quarter.

A great number of other measures are used in various trades, *e.g.* various multiples of the gallon, which are employed by dealers in wine, spirits, etc.

(4) *Weight.*

AVOIRDUPOIS WEIGHT.

16 drams = 1 ounce (*oz.*) = 437·5 grains.
16 oz. = 1 pound (*lb.*) = 7000 grains.
28 lb. = 1 quarter.
4 qrs. = 1 hundredweight (*cwt.*) = 112 lb.
20 cwt. = 1 ton = 2240 lb.

TROY WEIGHT.

24 grains = 1 pennyweight (*dwt.*)
20 pennyweights = 1 ounce (*oz.*) = 480 grains.
12 ounces = 1 pound.

The ounce troy is legal (but not compulsory) for the sale of gold, silver, precious stones, etc.

APOTHECARIES WEIGHT.

20 grains = 1 scruple.
3 scruples = 1 dram.
8 drams = 1 ounce.

The grain, ounce, and pound in Apothecaries Weight are the same as in Troy Weight. This measure is legal (but not compulsory) for the sale of drugs.

(5) *Angular Measure.*

60 seconds (60″) = 1 minute (1′).
60 minutes (60′) = 1 degree (1°).
90 degrees (90°) = 1 right angle.

(6) *Measures of Time.*

60 seconds = 1 minute.
60 minutes = 1 hour.
24 hours = 1 day = 86,400 seconds.

II. METRIC SYSTEM. This is a decimal system of weights and measures, in which only multiples of 10 are employed. It is used by most continental countries and their colonies, and in most scientific work.

The standard of length is the METRE, which was intended to be one ten-millionth of the earth's quadrant; it is now defined by a standard bar termed the *Mètre des Archives*, preserved by the French Government.

The multiples and sub-multiples of any unit are denoted by the following prefixes:

$\frac{1}{1000}$ of a unit by the prefix MILLI-.
$\frac{1}{100}$ " " " CENTI-.
$\frac{1}{10}$ " " " DECI-.
10 units by the prefix DECA-.
100 " " " HECTO-.
1,000 " " " KILO-.
10,000 " " " MYRIA.

(1) *Length.*

10 millimetres (*mm.*) = 1 centimetre (*cm.*)
10 centimetres = 1 decimetre.
10 decimetres = 1 metre (*m.*)
10 metres = 1 decametre.
10 decametres = 1 hectometre.
10 hectometres = 1 kilometre.
The metre = 39·371 inches.

(2) *Area.*

100 sq. mm. = 1 sq. cm.
100 sq. cm. = 1 sq. decimetre.
100 sq. decimetres = 1 sq. metre.
100 sq. metres = 1 sq. decametre or 1 are.

In measuring land, the are and its multiples are employed. 1 hectare = 2·471 acres.

(3) *Volume.*

The cubic centimetre and its multiples are used; a special name, the LITRE, is given to the cubic decimetre (1000 c.c.) and multiples of this measure are used. A cubic metre is termed a STERE.

The litre = 1·76 English pints.

(4) *Weight.*

The unit is the gram, which was intended to be the mass of a cubic centimetre of water at its maximum density. In practice it is $\frac{1}{1000}$ of the *Kilogramme des Archives.* (*Cf.* Metre.) The usual multiples, etc., are used; a special name, the TONNE, is given to 1000 kilograms.

1 gram = 15·432 grains.
1 tonne = ·9842 ton.
1 pound = 453·593 grams.

5. *Angular Measure.*

A decimal division of the right angle was drawn up in the eighteenth century, but is not in practical use. It was as follows:

100 seconds = 1 minute.
100 minutes = 1 grade.
100 grades = 1 right angle.

Weirs (*Civil Eng.*) A weir is a barrier placed across a stream in order to raise its level. SOLID WEIRS are banks of masonry, stones, piling, etc., usually of a triangular cross section, or walls of masonry, which may be combined with concrete. DRAW DOOR WEIRS possess vertical sliding doors, which can be raised in times of flood. A good example is found in the weir at Richmond (Surrey), in which doors 12 ft. high are raised and lowered by cables from the footbridge above. MOVABLE WEIRS are more or less temporary barriers; there are various forms, of which some of the commonest are as follows: NEEDLE WEIRS consist of a row of timbers placed vertically (or nearly so) across the stream, the bases resting against a sill, the tops against a continuous bar crossing the river. They are chiefly found in France and the Low Countries. PANEL WEIRS are of somewhat similar type, but wooden panels are substituted for the narrow timbers. CURTAIN WEIRS have a rolling partition, somewhat like the rolling shutter used in shops, special forms of hinge being used in order to produce a watertight joint. DRUM WEIRS have a shutter or leaf, hinged along one end and rotated in a DRUM or quadrant shaped cavity.

Weld (*Eng., etc.*) Welding is the process of forming a homogeneous joint between two pieces of iron (or mild steel) by heating them to a high temperature, termed a WELDING HEAT, rapidly cleaning off slag and other surface impurities, and pressing and hammering them together. A flux, such as clean sand or borax, is commonly used to facilitate the removal of oxide, etc., from the surface.

Welding Heat (*Eng., etc.*) A temperature of 2500° to 2700° F. in the case of wrought iron; steel welds at a lower temperature.

Weldon Process (*Chem.*) A process employed to reconvert the manganese chloride obtained in the preparation of chlorine from manganese dioxide and hydrochloric acid, into manganese dioxide again. The liquor from the chlorine still is allowed to settle; it is then neutralised with chalk, which also precipitates iron (present in native manganese dioxide); the clear liquor from this process is mixed with milk of lime heated to 55°, and air blown through it. This oxidises the manganese hydroxide precipitated by the milk of lime to manganese dioxide, which unites with some of the calcium hydroxide to form calcium manganite: the latter settles on standing—the deposit, known as Weldon mud, is used to generate chlorine $CaMnO_3 + 6HCl = CaCl_2 + MnCl_2 + 3H_2O + Cl_2$. Much less chlorine is made in this way now than formerly, so that this process is not so much used.

Wells. Wells are classified as DEEP or SHALLOW according to whether they do or do not pass through an impermeable stratum of sufficient thickness to cut off the surface water. The division is thus independent of the actual depth of the well. *See* ARTESIAN WELLS, SHALLOW WELLS, DEEP WELL WATER, *and under* SANITATION.

Welsbach Incandescent Mantle (*Chem.*) A mantle (*q.v.*) composed chiefly of thorium oxide, with 1 per cent. of cerium oxide. *See also under* FLAME, *p.* 224.

Welsh Harp (*Music*). A harp having three rows of strings, the two outside rows being in unison, and the inner so tuned as to complete the chromatic scale. It has the strings on the right side, and is held on the left shoulder. The treble is played with the left hand and the bass with the right. *See also* HARP, *p.* 429.

Welt (*Eng.*) The strip of iron laid over a butt joint (*q.v.*)

Welt Joint (*Plumb.*) A joint formed by folding the edges of sheet lead, zinc, etc., one over the other.

Wenlock Series (*Geol.*) The middle division of the SILURIAN ROCKS, equivalent to the SALOPIAN (*q.v.*)

Wernerite (*Min.*) A synonym for SCAPOLITE (*q.v.*)

Werner's Theory (*Chem.*) Is an extension of the theory of valency so as to explain the formation, constitution, and transformations of those complex compounds whose formation, constitution, and trans-

formations appear to be otherwise incapable of explanation. For instance, on none of the ordinary assumptions as to the valency of any of the elements of the following compounds can their existence be interpreted:

$$MgCl_2 6H_2O,\ K_3Co(NO_2)_6,\ Cr(NH_3)_6Cl_3,\ PtCl_6K_2$$

Werner assumes that those atoms which are able to form what may be called the central atoms of these complex compounds possess two kinds of valency—a Principal and a Subsidiary. The Principal Valency is the ordinary valency exhibited by the atoms in their simplest and most stable compounds, or it is the valency exhibited by the element or group when it exists in solution as an ion. The Subsidiary Valency is a residual valency exhibited by compounds formed from elements united by Principal Valency, and as such compounds can never be ions, or act as equivalent to ions, subsidiary valency may be defined as a valency which unites to each other compounds which can neither act as independent monovalent ions nor be equivalent to them. Compounds in whose formation only principal valencies are satisfied are called compounds of the first order; compounds formed by the union of compounds of the first order are called compounds of higher order. These definitions are illustrated by the following examples: (1) Sulphur trioxide unites with water to form sulphuric acid. This union is assumed to occur in the first place by means of the subsidiary valency of the sulphur in the trioxide and the oxygen in the water. This subsidiary valency is always shown by a dotted line. The union is expressed thus:

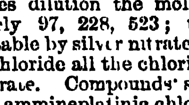
$$\begin{array}{c}O\\OS\\O\end{array} + OH_2 = \begin{array}{c}O\\OS\\O\end{array}\ldots OH_2$$

(2) A quite analogous case is the union of gold trichloride with hydrochloric acid to form chloroauric acid:

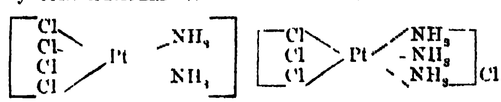
$$\begin{array}{c}Cl\\ClAu\\Cl\end{array} + ClH = \begin{array}{c}Cl\\ClAu\\Cl\end{array}\ldots ClH$$

(3) Platinic chloride unites with two molecules of hydrochloric acid and with two molecules of ammonia:

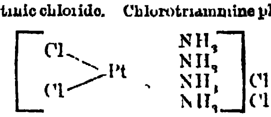
In examples (2) and (3) the subsidiary valencies of the compounds of the first order reside on the atoms joined by the dotted lines. It may be observed that on the ordinary theory of valency gold chloride, platinic chloride, hydrochloric acid, are all saturated compounds, yet we find them uniting to form quite stable compounds, and the same thing is observed in a very large number of cases, so that some such assumption as that of subsidiary valency appears to be fully justified. The principal valencies and the subsidiary valencies in compounds of higher order are not independent of each other. This is shown by the frequency with which compounds of higher order are formed from compounds of the first order which contain common elements, by the fact that many higher oxides in the free state are very unstable, while their salts are quite stable, by the fact that several higher chlorides, for instance, lead tetrachloride, are unstable, while their double chlorides are stable, *e.g.* $(NH_4)_2PbCl_6$, and finally by the fact that the subsidiary valency depends for its value on the nature of the elements or groups that satisfy the principal valencies, *e.g.* cadmium bromide unites with six molecules of pyridine, while the nitrate only takes up two. The number of subsidiary valencies of compounds of the first order is limited. This number is, of course, only capable of being deduced by considering all the compounds of higher order that can be formed from the compound of the first order under consideration. It probably never exceeds six; in platinic chloride, cobaltic salts, in the iron of ferricyanides, and in the iron of ferrocyanides it is two, three, three, and four respectively. The total number of atoms united directly to the central atom in compounds of higher order, whether they are united by a principal valency or a subsidiary valency, is called the co-ordination number. The maximum co-ordination number in the majority of cases is six; but it varies with the nature of the central element—in the cases of carbon and nitrogen it is four. Now consider the compound diammineplatinic chloride



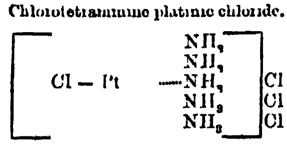
: it is unacted on by boiling sulphuric acid; silver nitrate does not give a precipitate of silver chloride when added to its solution; its solution shows no electrical conductivity. These facts show that the chlorine is quite incapable of behaving as the chlorine in an ordinary chloride—it is not ionisable. By taking up ammonia it can yield compounds containing one, two, and four more molecules of ammonia. These new compounds show electrical conductivity; at 1,000 litres dilution the molecular conductivity is respectively 97, 228, 523; the chlorine becomes precipitatable by silver nitrate, till in the hexammineplatinic chloride all the chlorine is precipitatable by silver nitrate. Compounds such as the tri-, tetra-, and hexa-ammineplatinic chlorides are called Interposition Compounds, because the entering ammonia molecules have displaced chlorine atoms in such a way that the ammonia molecules are now interposed between the chlorine atoms and the platinum atom, and the chlorine, as the ammonia has interposed, has become ionisable. These relationships are indicated by constitutional formulæ as follows:



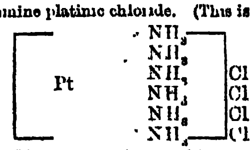
Diammine platinic chloride. Chlorotriammine platinic chloride.



Chlorotetrammine platinic chloride.



Chloropentammine platinic chloride. (This is yet unknown.)



Hexammine platinic chloride.

It is seen that in each compound there are six

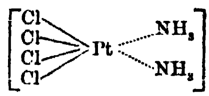
co-ordinated atoms or groups: these groups are assumed to occupy the space around the platinum atom, while the other atoms—those outside the brackets—are regarded as being in an outer sphere, but still acted on by the central platinum atom. It should be noticed that the maximum number of atoms that can occur in the outer sphere equals the maximum principal valency of the central atom. Also, it is the atoms of the outer sphere only that are ionisable. The platinum atom may be assumed to be at the centre of a regular octahedron and the co-ordinated groups at the angular points: the atoms outside the brackets in the above formulæ are assumed to be in an outer sphere in a way not yet specified. If the spacial arrangement just described be true, cases of isomerism should occur. For instance:

$$[Cl_2Pt(NH_3)_4]Br_2$$
(Dichlorotetrammine platibromide)

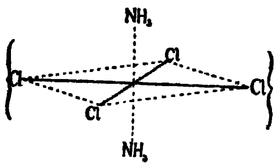
should be isomeric with

$$[Br_2Pt(NH_3)_4]Cl_2$$
(Dibromotetrammine platichloride)

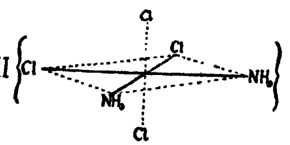
and this is found to be the case. Werner calls this ionisation isomerism. Many examples are known. Again, two compounds of the formula



should exist, namely:

I 

These have long been known, and I. is the diammine platinic chloride and II. the semidiammine platinic

II 

chloride. This kind of isomerism is called by Werner Space Isomerism. Many examples are known.

In compounds of the first order an element does not always act with its maximum principal valency; for instance, we have stannous chloride, $SnCl_2$, and stannic chloride, $SnCl_4$. So in compounds of higher order, a central atom does not always act with its maximum co-ordination number—that is, a series of co-ordinatively unsaturated compounds should exist. Several such series are known. These compounds also form interposition compounds; an example is:

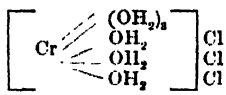
$[Pt(NH_3)_4]Cl_2$	$\left[Pt{(NH_3)_3 \atop Cl}\right]Cl$	$\left[Pt{(NH_3)_2 \atop Cl_2}\right]$
Tetrammine platochloride. 260.	Chlorotriammine platochloride. 116.	Dichlorodiammine platochloride. 0

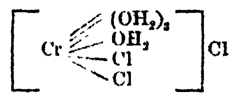
$\left[Pt{NH_3 \atop Cl_3}\right]K$	$[PtCl_4]K_2$
Potassium amminoplatochloride. 107.	Potassium platochloride. 267.

The numbers give the molecular conductivity at 1,000 litres dilution. These compounds can be represented graphically, as shown above, by abolishing the vertical axis; also isomerism should occur in the case of the dichlorodiammineplato chloride, and this is the case. To give even a list of the so-called "double salts" to which this theory has been applied, and applied with astonishing success, would far exceed the limits of this article; but a few examples are added: the complex cobalt-ammonium salts, the corresponding chromium salts, the complex double salts of vanadium, molybdenum, tungsten, the cobaltinitrites, etc. Many salts crystallise with six molecules of water of crystallisation; examples are:

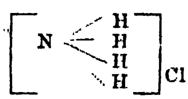
$$CaCl_2 6H_2O : AlCl_3 6H_2O : CoCl_2 6H_2O : Zn(NO_3)_2 6H_2O : CrCl_3 6H_2O$$

These are regarded as follows, $[Ca(OH_2)_6]Cl_2$—that is, the metal in the central element and the six molecules of water are co-ordinated with it through the subsidiary valency of the oxygen. A remarkable consequence of this is that on Werner's view the ions in these salts will be $\overset{2+}{[Ca(OH_2)_6]}$ and $2\,\overline{Cl}$. Another interesting point is furnished by the blue hexahydrate of chromium chloride—this loses two molecules of water readily and forms the green tetrahydrate. Now, all the chlorine of the hexahydrate is precipitated by silver nitrate, while only one-third of the chlorine is precipitated in the case of the tetrahydrate. These results are easily expressed by formulæ:

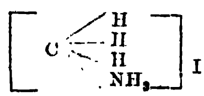




The theory offers a very natural account of the ammonium compounds. The co-ordination number for nitrogen is four, so we have—



which accounts, without any forcing, for the fact that ammonium salts behave like salts of the alkali metals, while the pentavalent nitrogen theory does not. The formation of the organic ammonium compounds is explained on the same plan as methylamine hydriodide:



A large number of acids containing four oxygen atoms is known. As typical of these may be mentioned:

$$[SiO_4]H_4, [PO_4]H_3, [SO_4]H_2, [ClO_4]H.$$

All these are regarded as co-ordinated compounds, and it will be noticed that the valency of the co-ordinated group diminishes in passing from Group IV. to Group VII. of the Periodic System. Now, there are oxides of Group VIII. of the Periodic System—*e.g.* RuO_4 and OsO_4—which are richer in oxygen than any of the oxides from which the above acids are derived, and it is remarkable that these oxides no longer unite with water to form acids. Thus in the majority of cases (a few exceptions are

known) four is the maximum co-ordination number for oxygen. In these cases also interposition compounds can exist; for example:

$$\left.\begin{array}{ccc} O & & O \\ & P & \\ O & & O \end{array}\right| H_3 \text{ Phosphoric acid (Tribasic);} \quad \left[\begin{array}{ccc} O & & O \\ & S & \\ O & & O \end{array}\right] H_2 \text{ Sulphuric acid (Dibasic);}$$

$$\left.\begin{array}{ccc} O & & O \\ & P & \\ O & & H \end{array}\right| H_2 \text{ Phosphorous acid (Dibasic);} \quad \begin{array}{ccc} O & & O \\ & S & \\ O & & H \end{array} H \text{ Suphurous acid (Dibasic);}$$

$$\begin{array}{ccc} O & & H \\ & P & \\ O & & H \end{array} H \text{ Hypophosphorous acid (Monobasic).}$$

That sulphurous acid is dibasic is to be explained on the supposition that sulphurous acid can react in the tautomeric forms—

$$\left[\begin{array}{ccc} O & & O \\ & S & \\ O & & H \end{array}\right] H \text{ and } \left[\begin{array}{ccc} O & & O \\ & S & \\ O & & . \end{array}\right] H_2$$

Cases are known in which tautomerism does in fact occur. The case of the heptahydrated sulphates (vitriols) is met by assuming that some molecules of water are co-ordinated with the metallic element, while some are co-ordinated with the acid residue; this case is apparently not yet worked out. Again, in salts like the alums, which contain a very large amount of water of crystallisation, it is necessary to assume the existence of double water molecules, which are co-ordinated like single atoms or molecules—an assumption which Werner justifies by pointing to the known molecular association of water in the liquid state. The cases of the vitriols and alums may be regarded therefore as either insufficiently examined as yet or as arguments against Werner's theory: but in view of the enormous number of compounds which this theory has rendered intelligible and capable of classification, the former appears the more probable assumption.

Westinghouse Brake (*Eng.*) *See* RAILWAYS, *p.* 599.

Wet and Dry Bulb Hygrometer (*Phys. and Meteorol.*) *See* HYGROMETERS.

Wet End (*Paper Manufac.*) The term applied to the portion of the machine where the wet pulp is made into a sheet of paper.

Wet Press Machine. *See* WOOD PULP.

Wet Puddling (*Met.*) *See* PIG BOILING.

Wet Steam (*Eng.*) Steam in which partial condensation has occurred, or which has been mixed with water spray in the boiler.

Wetting Board (*Print.*) A board placed between the reams of paper in the process of wetting down.

Wetting Down (*Print.*) Ordinary printing papers are occasionally wetted down before printing. The ream is quired and placed on the left of the wetting trough. A quire is then taken, and one end dipped in the water and the whole drawn through. A dry quire is placed on top of the wet one, and so on alternately. Boards are placed between and on top of the reams. Weights are put on top of the pile, and the paper allowed to soak for several hours. The sheets are then turned, and afterwards placed in a screw press and fastened down. The object of the process is to facilitate deposition of the ink evenly upon the paper.

w.f. (*Print.*) The abbreviation generally used for Wrong Fount (*q.v.*)

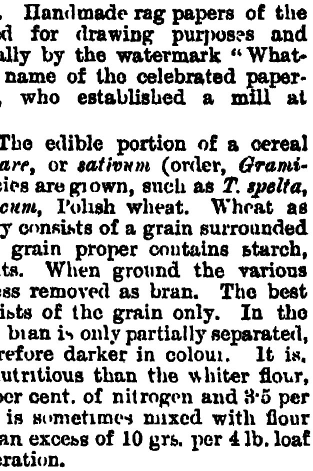
Whale Oil. The two kinds of whale oil of commerce are known as TRAIN OIL obtained from the Right Whale and certain other species, and SPERM OIL from the Sperm Whale. The latter is the most valuable lubricant for machinery known. *See* OILS *and* LUBRICANTS.

Wharfedale Machine (*Print.*) *See* TYPOGRAPHY.

Whatman Papers. Handmade rag papers of the highest quality used for drawing purposes and ledgers, known specially by the watermark "Whatman," this being the name of the celebrated paper-maker J. Whatman, who established a mill at Maidstone in 1760.

Wheat (*Foods*). The edible portion of a cereal grass, *Triticum vulgare*, or *sativum* (order, *Gramineæ*.) Many subspecies are grown, such as *T. spelta*, the Spelt; *T. polonicum*, Polish wheat. Wheat as grown in this country consists of a grain surrounded by four coats. The grain proper contains starch, proteid, fat, and salts. When ground the various coats are more or less removed as bran. The best quality of flour consists of the grain only. In the second-rate flours the bran is only partially separated, and the flour is therefore darker in colour. It is, nevertheless, more nutritious than the whiter flour, as bran contains 15 per cent. of nitrogen and 3·5 per cent. of fat. Alum is sometimes mixed with flour to render it whiter; an excess of 10 grs. per 4 lb. loaf is regarded as adulteration.

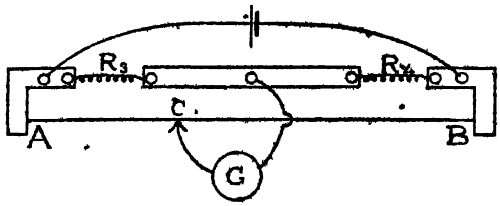
Wheatstone's Bridge (*Elect.*) An arrangement in which two resistances whose ratio is known are employed for the comparison of two other resistances, one of which is variable. Let R_1 and R_2 be two resistances whose ratio is known, or RATIO ARMS, R_3 a resistance which can be varied, R_4 an unknown resistance. These are connected with each other and with a battery B, and galvanometer G, as shown. R_3 is now adjusted till no current flows through G; when this is the case, it can easily be shown that—



$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \text{ or } R_4 = R_3 \times \frac{R_2}{R_1}.$$

Thus if R_3 and the ratio $\frac{R_2}{R_1}$ be known, R_4 is determined. When this relation is satisfied, the two conductors which contain the battery and the galvanometer respectively are said to be CONJUGATE CONDUCTORS; their relation is such that an electromotive force in one of them does not affect any current which may be flowing in the other. Hence any alteration in the E.M.F. of the battery has no effect on the accuracy of the measurements made with the bridge. The most typical forms of bridge are the SLIDE WIRE BRIDGE and the POST OFFICE

Box. In the former, the ratio arms are formed by a straight bare wire of German silver, or other suitable alloy, AB. This is mounted on a base board and



connected with the resistances R_3 and R_4 by heavy copper or brass conductors. The battery is connected as shown: one end of the wire from the galvanometer G goes to the conductor connecting R_3 and R_4, the other end, C, terminates in a sliding contact which can be moved along AB till a "balance" is obtained, *i.e.* until no current flows through the galvanometer. The lengths AC and BC are read off on a scale and the ratio of their lengths gives the ratio of the resistances of the portions AC and BC, *i.e.* the ratio of R_1 to R_2. As AB is commonly made 1 metre long, this form of bridge is often termed the METRE BRIDGE; it is also in a modified form known as the B A. BRIDGE (British Association).

In the Post Office Box, the ratio arms are usually formed by two sets of resistance coils, each set containing 10, 100, and 1000 ohms, either of which can be included in the circuit by means of plugs. The arm R_3 is formed by a set of coils which can be used singly or in combination so as to give resistances increasing by single ohms from 1 to 10,000 or more. The top of the box carries the plugs by which contacts are made, binding screws for connecting the battery, etc., and keys by which the battery and galvanometer circuits are made and broken. The method of use is based upon the same general principles as the foregoing. A DIAL BRIDGE is one in which the resistances are varied by moving a radial arm over a series of metal studs connected with the coils, thus avoiding the use of loose plugs.

Wheel Base (*Eng., etc*) The distance between the centres of the fore and hind wheels of a cycle, motor car, locomotive, etc.

Wheel Cutting (*Eng.*) The process of forming the teeth of wheels by a rotating cutter of the proper cross-section.

Wheel Moulding (*Foundry*). Forming the mould for casting toothed wheels Instead of using a complete pattern, a segment of the wheel is employed in many cases, in conjunction with a moulding machine (*q v.*)

Wheel Ore (*Min.*) A synonym for BOURNONITE (*q.v*)

Wheel Swarf (*Eng*, *etc*) The material removed from a grindstone and from the object being ground; it forms the muddy deposit in the trough under the stone and is sometimes utilised in metallurgical operations.

Wheel Teeth (*Eng.*) Wheel teeth must be so shaped that smooth sliding contact occurs in every position without variations in the velocity ratio of the two wheels; and further, the shape must be such as to give the necessary strength and ease of construction. In practice the curves adopted are nearly always portions of cycloidal curves (*see* EPICYCLOID *and* HYPOCYCLOID). The PITCH CIRCLES of two toothed wheels are two imaginary circles of such diameter that they would roll together with the same relative angular velocities as the actual toothed wheels. The teeth lie partly inside the circle and partly outside; the portion of a tooth within the pitch circle is called the ROOT, and the portion outside is called the POINT, or ADDENDUM. The profile of the teeth is the path traced out by a point on an imaginary circle, termed a DESCRIBING CIRCLE, which rolls on the pitch circles so as to be in contact with both, *i.e.* which touches both the pitch circles at their point of contact. If the same describing circle be used for any number of wheels they will all work with one another correctly, whatever their diameters. The diameter of the pitch circle must not, however, be less than half that of the smallest wheel in the set In this case the flanks (or profiles of the roots) of the smallest wheel are radial lines.

Another form sometimes given to teeth is the INVOLUTE, the curve generated by a point in a string which is being unwound from a cylindrical surface and kept tight throughout the operation. The whole profile of an involute tooth is one continuous curve; and wheels with such teeth possess the peculiar property that the centres of two wheels gearing with one another may be brought nearer together or farther apart without affecting the uniformity of their action or their velocity ratio.

Wheel Window (*Architect.*) *See* ROSE WINDOW.

Whetstone. A piece of fine grained hard stone, *e g.* slate, or an artificial stone of the same character, suitably fixed, used for sharpening cutlery and tools.

Whiffle *or* **Whipple Trees.** The horizontal bars by which horses are yoked to a vehicle.

Whim (*Mining*) A primitive form of winding machine, consisting of a drum mounted on a vertical axis, worked by a horse, or even by manual labour.

Whin *or* **Whinstone** (*Geol.*) A term often used locally by miners and quarrymen for any hard rock, *e g.* Basalt. The WHIN SILL is a great eruptive sheet cutting across the Carboniferous Rocks of the Pennines, and forming many striking physical features, such as crags and waterfalls

Whipping (*Bind.*) This term signifies the same process as OVERCASTING (*q.v.*), except that the stitches are longer.

Whipple-Murphy Girder (*Eng*) A form of built-up girder having its bars arranged in the form of the letter N.

Whip Threads (*Textile Manufac*) Threads in gauze weaving which whip or twist round adjacent threads.

Whirlwind (*Meteorol.*) Circular air movements set up by the meeting of two air currents differing in direction.

Whisky. A spirit originally distilled from malted grain, containing about 50 per cent of alcohol.

White Arsenic (*Chem*) *See* ARSENIC COMPOUNDS.

—— (*Min*) Occurs occasionally native as an incrustation on minerals containing arsenic.

White Cast Iron (*Chem.*) *See* IRON.

Whitefriars Machine. (*Print.*) A rotary machine designed for the printing of newspapers from single sheets or reels. It consists of four cylinders arranged round a crescent-shaped frame, the inking arrangements being placed at each end.

White Heat. The temperature at which a body emits white light. The "white heat" of the smith is the temperature to which a large piece of iron is heated before removal from the fire. It is between 1300° and 1500° C.

White Lead (*Chem.*) See LEAD COMPOUNDS.

White Lead Ore (*Min.*) A synonym for CERUSSITE (*q.v.*)

White Light (*Phys.*) Light in which all the colours of the spectrum are present in their proper proportion. See SPECTRUM.

White Line (*Print.*) A line of quadrats forming (*a*) a blank space in the text equal to one line, (*b*) the foot line of a page.

White Metal. Another name for BABBITT'S METAL (*q.v.*) See also COPPER and TIN.

White Nickel (*Min.*) A synonym for CLOANTHITE (*q.v.*)

White Out (*Typog.*) To space out lines or matter in order to give it a more open appearance.

White Paper (*Print.*) A technical term for all unprinted paper white or coloured.

White Precipitate (*Chem.*) See MERCURY COMPOUNDS.

White Soap. Soap manufactured by boiling fat with caustic lye, removing the imperfect and unformed soap by means of common salt, reboiling after the removal of the waste lye, and finally cooling. Sometimes an additional boiling is given, and the soap thus made may be used as the base or stock of toilet soaps (*q.v.*) Curd soap, according to the British Pharmacopœia, must be made from soda and a purified animal fat consisting principally of stearin. See SOAP MANUFACTURE.

White Squalls (*Meteorol.*) These are fair weather squalls, and occur when conditions are suitable for spout formation but sufficient moisture is wanting to fill up the central vortex.

White Vitriol. A trade name for sulphate of zinc. See ZINC COMPOUNDS.

—— (*Min.*) A synonym for GOSLARITE (*q.v.*)

Whitewash (*Build.*) Chalk lime mixed with water. A little tallow is added to prevent it being rubbed off when dry.

White Wood. See WOODS.

Whiting. Pure white chalk which has been ground and washed.

Whitworth Thread (*Eng.*) See SCREW THREADS.

Whole Bound (*Bind.*) See FULL BOUND.

Whole Note (*Music*) The semibreve (*q.v.*)

Whole Plate (*Photo.*) A plate measuring 8½ by 6½ inches.

Whorl (*Botany*) An arrangement of the parts of a plant in which a number spring from the same point, and are arranged regularly round the stem.

Wick. See CANDLES.

Wicket. A small door or gate used as a subsidiary entrance in a large opening, and sometimes forming part of a larger door.

Wickets (*Chem. Eng.*) Gratings of lead, used in the manufacture of WHITE LEAD. See LEAD COMPOUNDS.

Wide Gauge (*Railways*). The BROAD GAUGE (*q.v.*)

Wide Spacing (*Typog.*) So termed when two thick spaces or more are placed between the words, as in this definition.

Wilhelmite (*Min.*) A silicate of zinc, hexagonal, yellow to brown. Found in Belgium and the United States.

Willow. See WOODS.

Willowing Machine (*Paper Manufac.*) The apparatus used for removing dust from esparto and other fibres.

Willow Leaves (*Astron.*) The name given to the visible structure in the penumbra of sun-spots.

Wimshurst Machine (*Elect.*) The best form of electrical influence machine. The typical form consists of two discs of glass, each carrying a number of sectors of tinfoil, and mounted so that they are rotated in opposite directions by turning a single handle. Each disc is touched by two uninsulated brushes, carried by the "neutralising rods." If any one sector receive a charge it induces charges of the opposite sign on sectors which are moving past it in the opposite direction; the result is the accumulation of continually increasing charges of positive and negative electricity at opposite edges of the discs, and these charges are collected by conductors suitably placed for the purpose. Large machines are also made with four, six, or more plates.

Winch (*Eng.*) Hauling or hoisting mechanism, consisting of a barrel round which a rope or chain is wound, and either provided with a handle and the necessary gearing for hand driving, or connected with a steam engine, electric, or other motor for power driving.

Wind (*Meteorol.*) Air in motion is called wind. Unequal heating gives rise to air motion or air currents, the passage of which gives the phenomenon of wind.

Wind Direction (*Meteorol.*) The direction from which the wind blows. It is indicated by means of a vane.

Winding (*Carp., etc.*) The surface of a piece of work is said to be "in winding" or to "wind," if it gradually twists.

—— (*Elect. Eng.*) The conductors of a dynamo, coil, electro-magnet, transformer, etc., which carry the electric current.

—— (*Textiles*) A convenient method of transferring the yarn from hank, cop, or bobbin, one thread at a time, for a considerable length, on to a bobbin or tube, *i.e.* cop winding, drum winding, pirn winding.

—— and **Winding Engine** (*Mining*) See MINING, *p.* 405.

Winding Sticks or **Strips** (*Carp. and Join., etc.*) Two pieces of wood with parallel edges used by joiners to show whether wood is winding. The strips are placed on edge on the wood to be tested, and the eye placed on a level with their upper edges, when any want of parallelism due to twisting or winding of the wood is at once seen.

Winding-up Tackle (*Lace Manufac.*) Worm and wheel gearing connected to the work roller, one of the factors determining the quality of the lace; analogous to the "taking off" motion in the loom.

Wind Instruments (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 431.

Windlass. A simple form of hand winch without gearing. *See* WINCH.

Windmill. A modern windmill consists of a set of radial vanes set at an angle capable of adjustment, and forming an almost complete disc, instead of having four or six vanes, as in the old form, which is still a familiar object in many districts. Owing to the uncertain and intermittent action of the wind, this form of motor is now little used, except for pumping water for drainage of land, irrigation, or filling tanks for small water supplies, where an occasional interruption in the flow is of no importance.

Window Board (*Build.*) The nosing board fixed to the sill inside a room.

Wind Pressure (*Eng., Build., etc.*) In large modern structures a wind pressure of 56 lb. per square foot is allowed for in calculating the strength of the members. It is very unlikely that the actual pressure ever exceeds 40 lb. The former limit was fixed by the Board of Trade after the Tay Bridge disaster in 1879.

—— (*Meteorol.*) The pressure or force exerted by the wind. Measured by the pressure it exerts on a flat surface placed perpendicular to its direction of motion.

Wind Trunk (*Music*). The tube which conveys the wind from the bellows to the wind chest.

Wind Velocity (*Meteorol.*) The rate of movement of wind. Measured by an anemometer (*q.v.*)

Wines. Light or natural wines contain from 6 to 13 per cent. of alcohol; strong or fortified wines, such as port and sherry, contain from 12 to 22 per cent. Besides alcohol, wines contain various aromatic ethers, which give the characteristic flavour or bouquet, sugar, acids, and salts.

Winged Globe (*Architect.*) One of the symbolical ornaments used by the Egyptians; a globe with outstretched wings. A scarab (sacred beetle), vulture, or a representation of the goddess Isis is frequently used instead of the globe.

Wing Nut (*Eng., etc.*) A nut provided with "wings" or projections, by means of which it may be turned by the thumb and fingers.

Wing Valve (*Eng.*) A valve provided with projections to guide it into its proper position.

Winning (*Mining*). A miners' term for the process of obtaining coal from the seam. *See* MINING.

Wincey (*Textile Manufac.*) A fabric with a rough, hard handle, formerly used for dresses.

Winter Solstice (*Astron.*) *See* SOLSTICES.

Wipe (*Print.*) A term used when the rollers leave an excess of ink on the edges of the forme.

Wiped Joints (*Plumb.*) A method of joining lead pipes. The upper end of the lower pipe is opened out about ¼ inch, and the lower end of the upper pipe is rasped so as to fit into the opened-out end. The ends of the pipes are then shaved so as to allow the solder to adhere to them. The pipes are next soiled above and below the soldering line with a mixture of lampblack and size, and the upper pipe is fixed into the lower with a collar round the bottom of the joint to catch the solder. The heated solder is then poured over the shaved ends of the pipes and worked into shape, the final process being the "wiping" of the joint with a hot moleskin cloth.

Wiper (*Weaving*). Another term for an eccentric or tappet. *See* TAPPET *and* LOOM.

Wire. Wire may be made of any metal possessing sufficient ductility to allow of drawing. Iron, steel, copper, and brass wire are the most common in the arts; the precious metals are also made into wire for decorative and other special purposes.

—— (*Textiles*). Used in velvet weaving to form the pile. Made of brass, flattened at the sides and having a groove through its entire length on the upper surface. It is placed in the shed under the pile warp, transversely, and is cut out as necessary by a sharp instrument called a truvat. The length of pile is regulated by the height and size of the wire. Wires for Terry (*q.v.*) weaving are quite round and made of steel.

Wire Brush. A brush made either entirely or partly of wire. Wire brushes are used for various purposes, *e.g.* by gilders for spreading gilt, for cleaning castings, etc.

Wire Card. *See* CARD WIRE.

Wire Cloth (*Paper Manufac.*) An endless cloth made of very fine wire, upon which pulp is formed into a sheet of paper.

Wire Drawing (*Eng., etc.*) (1) The production of wire by drawing a rod of metal through a hole in a steel plate of slightly smaller diameter than the rod; the process is repeated with successively smaller holes until wire of the requisite fineness has been obtained. (2) The reduction of the pressure of steam when it is caused to flow through narrow passages.

Wire Edge. The thin burr thrown up on the edge of a tool during grinding or sharpening on a stone.

Wire Gauge (*Eng.*) (1) A tool used for testing the diameter of wire or the thickness of metal plate. (2) A set of standard diameters to which wire, etc., is made, each designated by a special number. The BIRMINGHAM WIRE GAUGE (B.W.G.) is the one most commonly used, but others are also employed, *e.g.* the AMERICAN, *or* BROWN AND SHARPE, GAUGE. The numbers and diameters in inches of some of the principal sizes are as follows:

Number of Wire.	Diameter on Birmingham Wire Gauge.	Diameter on American Wire Gauge.
0	·340	·325
1	·3	·289
2	·284	·257
4	·238	·204
6	·203	·162
8	·165	·128
10	·134	·102
12	·109	·08
14	·083	·064
16	·065	·0508
18	·049	·0403
20	·035	·03196
25	·02	·0179
30	·012	·01
35	·005	·0056

Wire Micrometer (*Astron.*) *See* MICROMETER.

Wire Rope (*Eng.*) Rope formed by twisting fine wires of iron or steel, a hempen core being usually employed.

Witch Hazel (*Botany*). The dried bark and leaves of *Hamamelis virginica* (order, *Hamamelidaceæ*) are used in the preparation of a valuable astringent drug.

Witherite (*Min.*) Barium carbonate, $BaCO_3$; rhombic; in compound crystals; white to grey. Used as a source of barium compounds; also in sugar refining, porcelain and plate glass manufacture, and as a ratbane. In many localities in the Alston Moor District, in Central Europe, etc.

Withes (*Build.*) The partitions between the flues in a chimney stack.

Witness (*Bind.*) In the case of a book that is not to be "cut down" the edges are merely trimmed so as to make them straight and true. Some of the leaves still retain their rough edges, which are "witness" of the proper treatment.

Woad. A blue dye obtained from the pounded leaves of *Isatis tinctoria* (order, *Cruciferæ*). It is now replaced by indigo. *See* DYES AND DYEING.

Woad Vat. *See* DYES AND DYEING.

Wohltemperirte Klavier, Das (*Music*). The Well-Tempered Clavichord, the name given to "The 48 Preludes and Fugues" by J. S. Bach, who wrote them to show that by the new Equal Temperament tuning every key from C to B, both major and minor, was available.

Wolfram (*Chem.*) *See* TUNGSTEN.

—— (*Min.*) A tungstate of iron and manganese, the amounts of the two bases being variable. Monosymmetric, with a perfect cleavage; commonly found massive. Found in Cornwall, Cumberland, and in many other localities in Europe and America. It is used in the hardening of steel, for the fire-proofing of textile fabrics (as sodium tungstate), as a mordant, and in hardening plaster of Paris.

Wolframine (*Min.*) *See* TUNGSTIC OCHRE.

Wolf Rayet Stars (*Astron.*) A peculiar class of stars which have bright lines in their spectra.

Wolf, The (*Music*). A harsh, howling effect in certain intervals on keyed instruments tuned to the unequal temperament. This system was discarded in favour of the equal temperament in England about 1830 on the pianoforte, and about 25 years later on the organ.

Wollastonite (*Min.*) Also termed TABULAR SPAR. A metasilicate of lime, $CaOSiO_2$. Monosymmetric, but usually found massive. Colour white to reddish brown, translucent. Occurs in granite and certain other rocks.

Wood Block. A block of wood prepared for engraving. *See* ENGRAVING, *p.* 202, *and* WOODCUT.

Wood Carving. *See* CARVING.

Woodcut. An engraved wood block bearing a picture or design and made type high for use in a printing press. A print from such a block.

Wood Engraving. *See* ENGRAVING.

Wood Furniture (*Typog.*) Material used for dressing or imposing a forme. Of various thicknesses, and designated narrow, broad, double narrow, and double broad. *See* FURNITURE.

Wood Letter (*Typog.*) Large types cut in wood for use in posters for advertising, etc.

Wood Oil (*Botany*). *See* GURJUM BALSAM.

Wood Opal (*Min.*) Wood of which the tissues have been replaced by silica in the hydrous form Opal.

Wood Paving (*Civil Eng.*) This consists of a foundation or "formation" of concrete, carefully levelled; on this are laid the blocks, which are usually 9 in. long, 6 in. deep, and 3 in. wide. The blocks are laid with the fibres vertical, and the rows are at right angles to the main direction of the traffic. The joints between the blocks are filled with cement grout (thin, fluid cement) or with melted pitch; or both may be employed. The usual materials are certain of the Australian hard woods, *e.g.* blue gum, red gum, Jarrah, etc.

Wood Pulp. The use of wood pulp as a raw material suitable for the manufacture of paper dates from the year 1866. Attempts had been made previously to introduce wood for the purpose, but without material success. In 1801 Matthias Koops printed a book, the paper of which consisted almost entirely of wood pulp, though the method of manufacture was very crude. The industry received an impetus from the efforts of Voelter, who obtained patents in 1860 for the preparation of MECHANICAL WOOD; and in 1866 by the introduction of methods for the preparation of CHEMICAL WOOD PULP by Tilghmann, notably by the *sulphite* process. The employment of wood pulp in the papermaking industry has since been followed by its application to purposes of a very different character. The processes for converting wood into pulp are of two kinds: (1) Mechanical, in which the wood is treated by purely mechanical agencies. (2) Chemical, in which a pure form of cellulose is obtained by drastic chemical treatment.

(1) MECHANICAL WOOD PULP.—The trees suitable for the manufacture of pulp, *e.g.* poplar, fir, and pine, are felled in the early part of the winter and cut into lengths of 12, 14, and 16 ft. The logs are then conveyed to the pulp mill, where they are cut into lengths of 2 ft. by powerful circular saws, and the outer bark is removed by special machinery. The refuse is blown away and utilised as fuel, and the clean 2-ft. pieces of wood are then converted into pulp by means of grinders, *i.e.* large grindstones mounted on heavy shafts and fitted with appliances by means of which the blocks of wood are forced against the stones by hydraulic pressure. The blocks of wood are thus ground into fibrous material, and the product is mixed with large quantities of water and passed through screens—shallow boxes, the bottoms of which consist of brass plates containing very fine narrow slits. The finely screened pulp is then put through what is known as a "wet press machine," in order to remove the excess of water and convert the pulp into a thick sheet. The sheets thus obtained are folded to a uniform size, subjected to heavy pressure, packed up in suitable covering, and despatched to the paper mill.

(2) CHEMICAL WOOD PULP.—There are several processes in use for the manufacture of chemical pulp, *e.g.* the caustic soda method and the bisulphite of lime process, the latter being in general use. The following is a brief description of the sulphite process: The logs, having been barked and cut up into 2-ft. lengths, are chipped up into small pieces, about the size of a cork, by special machinery, and

then transferred to the digesters—huge steel vessels lined with bricks or cement, in which the wood is boiled under pressure with a solution of bisulphite of lime. This powerful reagent is prepared by allowing the fumes of burning sulphur to act upon moist masses of limestone, which are kept wet by a stream of water under properly regulated conditions. The digesters employed are sometimes of enormous size, capable of taking no less than twenty tons of wood at one turn. After digestion for eight to nine hours under a pressure of 80 lb., the contents of the boiler are blown out into tanks and washed thoroughly to remove the spent liquor. The weight of pulp obtained is only 50 per cent. of the original wood, so that a loss of 50 per cent. is sustained in the manufacture of the chemical wood, the by-products having little or no commercial value. The pulp after washing is screened and converted into thick sheets in the same manner as the mechanical pulp. The pulp is also obtained in the form of dry sheets by the use of a machine similar in construction and principle to the ordinary paper machine. The pulp so prepared is then ready as a raw material for other industries. The sulphite pulp is blended with mechanical pulp in varying proportions for the production of cheap printings and newspaper. A well cooked pulp gives a pure *cellulose* almost equal to that derived from rags. The marked deterioration in the quality of ordinary paper, and the lack of durability, may be traced in a very large measure to the presence of mechanical wood pulp. The durability of any paper is in direct proportion to the percentage of absolutely pure cellulose, this material being easily isolated from the best quality of rags, since the amount of chemical treatment necessary is reduced to a minimum. In the case of Mechanical wood pulp the whole of the resinous and non-fibrous constituents of the wood are present, and these constituents are liable to chemical changes, probably due to moisture and other atmospheric conditions. In the case of Sulphite wood pulp the purity of the cellulose is mainly a question of careful manipulation. One ton of ORDINARY NEWSPAPER consists of Mechanical wood pulp and Sulphite wood pulp in the proportion of 75 and 25 per cent. respectively, together with a certain proportion of mineral matter. The quantity of wood pulp required for this amount of paper is 1,680 lb. of Mechanical pulp and 560 lb. of Sulphite approximately, nearly one cord of wood being required to produce the former and about half a cord to produce the latter. A "cord of wood" consists of logs 4 ft. long, packed together so as to form a pile 8 ft. by 4 ft., giving a total capacity of 128 cubic ft. This is the usually accepted unit of measurement for pulp wood logs. It is calculated that for logs having an average diameter of 12 in., about fifty-four pieces, each 4 ft. long, will make one and a half cords, which is the quantity necessary for a ton of cheap newspaper. The number of trees required to produce this amount of wood will, of course, vary. Assuming that the trees are about 60 ft. high to the crown, then five of these trees will be necessary to produce sufficient pulp for the production of the paper.

Wood pulp is now employed as the basis of many highly interesting commercial products, which at first sight would appear to have little or nothing in common with wood. If treated with nitric acid under special conditions, nitrates of cellulose are formed which, when dissolved in a mixture of ether and alcohol, give COLLODION SOLUTION (*see* CELLULOSE *and* COLLODION), a well-known substance used in photography. Varying the conditions of nitration, as, for example, by prolonged treatment with nitric acid, other nitrated compounds are produced, and these find employment as GUN COTTON (*q.v.*), which is used in blasting. If gun cotton is incorporated with camphor by suitable mechanical means, a plastic body is produced known as CELLULOID (*q.v.*), a material capable of being moulded into a great variety of shapes, and coloured many shades. A similar product to celluloid is the well known Xylonite (*q.v.*) Then, again, by careful preparation of certain nitrates of the cellulose, and by modifying the conditions of their production, SMOKELESS POWDERS are obtained, such as Cordite, Ballistite, etc. By mixing the nitrocellulose with nitrobenzene or camphor in definite proportions, other well known explosives, such as E.C. and S.S. SPORTING POWDERS, are obtained. By treating wood cellulose with strong caustic soda, and submitting the product to the action of bisulphide of carbon, a soluble product is formed, which is extremely viscous. This viscous solution has the property of "setting" to a hard mass, and is capable of being manipulated into articles closely resembling ebony and vulcanite. The commercial applications of VISCOSE are numerous. The soluble solutions can be converted into insoluble bodies, and then employed for the manufacture of explosives. One of the most interesting applications of Wood Pulp is the manufacture of ARTIFICIAL SILK (*see* CELLULOSE). This substance is obtained by producing cellulose nitrates under special conditions and dissolving the nitrates in suitable mixtures of ether and alcohol. The viscose solution obtained is forced through extremely fine orifices into water, with the result that the solution produces an insoluble compound in the form of a thread. A number of threads are suitably twisted together and wound into the form of a hank. The resulting yarn is treated chemically in order to remove the combined nitric acid, which if left in would give a highly explosive compound, and the substance eventually obtained is a pure cellulose, capable of being dyed most brilliant colours, and endowed with a very high lustre.—R. W. S.

Woods. *Classification.*—A complete classification of woods can only be made on botanical principles. The *Coniferæ* include the great majority of those known as SOFT WOODS, which are used in general carpentry and joinery, and the practice has arisen of denominating most other timbers as HARD WOODS for trade purposes. The subjoined table gives the genus and species of various trees, followed by the name of the order (in brackets).

Preparation of Timber for the Market.—This includes (1) FELLING, (2) SQUARING, (3) SEASONING, and (4) CONVERSION. When the tree has been felled it should be roughly squared, that the air may come into contact with the wood, when the seasoning or drying process at once commences. In many cases the log is further cut in order to accelerate the process. It is then freely exposed to the air, but protected from damp and direct sun for a period which may vary from three months to two or three years, according to the kind of wood, the uses to which it is to be put, etc. ARTIFICIAL SEASONING is effected by drying with hot air, sometimes preceded

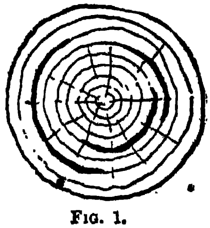


FIG. 1.

by soaking in water. CONVERSION is the sawing of the timber into the sizes required for the market; this should be followed, if possible, by further seasoning.

Defects of Timber.—SHAKES are cracks or flaws in the wood, which may have occurred during growth or which may be due to unequal shrinkage. CUP SHAKES are clefts following the annual rings (fig. 1). HEART SHAKES consist of clefts which cross the pith and widen out as they approach it (fig. 2). STAR SHAKES (fig. 3) widen towards the bark. RHIND GALLS are defects produced by growth of fresh layers over an injury sustained by the outside of the tree during growth. Local decay produces defects known as FOXINESS. WET ROT is produced by decay during growth, and is due to the attack of fungi. DRY ROT, to which timber is liable after seasoning, is also due to fungi; but the name is misleading, inasmuch as it only occurs in the presence of moisture and the absence of free circulation of air.

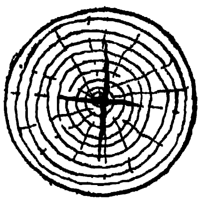


FIG. 2.

Preservation.—The first essential to successful preservation is good seasoning; but various artificial means are also very valuable. Such are CREOSOTING and KYANISING (*q.v.*) CARBONISING or charring the surface is valuable for preserving parts of timber, such as posts, buried in the ground. Impregnation with zinc chloride (BURNETT'S PROCESS, *q.v.*) and with copper sulphate are other methods, but they are inferior to creosoting.

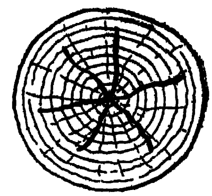


FIG. 3.

Common Names.	Botanical Name.	Localities.	Characteristics.	Uses.
Acacia (Locust)	*Robinia pseudacacia*	—	*See* LOCUST.	—
Acacia .	*Eucryphia moorei* (*Rosaceæ*)	Australia .	Fairly hard; grows to a large size	Carriage work.
Alder . . .	*Alnus glutinosa* (*Betulaceæ*)	Europe; America	Soft, light, smooth grain; light brownish tint; durable in water	Piles, sluices, and other submerged work; barrels, clog soles; also used for making charcoal for gunpowder.
Amboyna-wood	*Pterocarpus* (*Leguminosæ*)	E. Indies .	Hard, well marked, very ornamental, and capable of a high polish; colour orange to brown; scented	Inlaying and small decorative work.
Angelique .	*Dicorynia* (*Leguminosæ*)	Brazil. . .	Hard, durable in sea-water . .	Shipbuilding work.
Apple . . .	*Pyrus malus* (*Rosaceæ*)	—	Hard, heavy, brittle	Turnery.
Ash. . . .	*Fraxinus excelsior* (*Oleaceæ*)	Europe . .	Tough, flexible, fairly hard, close grain. Distinctly marked grain, light colour.	Many purposes where flexibility and toughness are essential—*e.g.* hoops, handles for hammers and other tools, shafts of vehicles, wheels; cabinet making.
Ash, American	*Fraxinus americana*	America. .	Closer, and of lighter colour, than the common Ash.	Used for much the same purpose as the common Ash.
Ash, Mountain (Rowan)	*Pyrus aucuparia* (*Rosaceæ*)	Europe, Asia	White to reddish white. . . .	Occasionally used in turnery.
Aspen. . .	*Populus tremula*. (*Salicineæ*)	Europe .	Light and soft; nearly white or slightly tinted with brown	Turnery and miscellaneous small work.
Aspen, American	*Populus tremuloides*	N. America.	Resembles the European Aspen	Turnery; wood-pulp.
Basswood .	*Tilia americana* (*Tiliaceæ*)	N. America.	Light, soft, but fairly tough and close-grained; white to light brown in colour	Turnery and miscellaneous. N.B.—The name is sometimes applied erroneously to American WHITE WOOD, or *Liriodendron tulipifera* (*q.v.*)
Beech . . .	*Fagus sylvatica*. (*Cupuliferæ*)	Europe . .	Heavy, hard, very strong and tough; colour varies from white to almost red.	Turned work, planes, tool handles, wooden screws and nuts, wheel cogs, printers' wood work. On the Continent for fuel and charcoal.

Common Names.	Botanical Name.	Localities.	Characteristics.	Uses.
Birch . . .	*Betula alba* (*Betulaceæ*)	Europe . .	Fine grain, fairly strong; colour yellowish white to brown	Furniture and turnery. The twigs are used in making hoops, crates, etc., in tanning, and for burning in smoking provisions. The bark has also been put to many uses.
Blackwood .	*Acacia melanoxylon* (*Leguminosæ*)	Australia .	Hard, even, fine grain	Ornamental work; also for casks, turnery, and miscellaneous purposes.
Blackwood, Indian	*Dalbergia* (*Leguminosæ*)	India . . .	Hard, tough, cross-grained; takes a good polish	Sleepers, and various local uses; imported for cabinet making.
Box . . .	*Buxus sempervirens* (*Euphorbiaceæ*)	Europe, Asia, N. Africa	Very close grain: hard; colour light yellow	The chief wood in wood engraving, turnery, etc.
Briar-wood (Bruyère)	*Erica arborea* (*Ericaceæ*)	S. Europe .	Small tree; heavy, brown mottled wood	Tobacco pipes. From the French name *Bruyère* is derived the common name "Briar" as applied to pipes.
Butternut (White Walnut)	*Juglans cinerea* (*Juglandaceæ*)	N. America.	Soft, but not attacked by insects	Sleepers and miscellaneous uses, in America.
Canary, American (American whitewood)	*Liriodendron* . .	—	*See* WHITEWOOD.	—
Canary-wood	*Morinda citrifolia* (*Rubiaceæ*)	E. Indies, Australia	Yellow, handsome markings, and capable of a fine polish	Turnery, cabinet work.
Cedar (true).	*Cedrus libani* . . (*Coniferæ*)	Asia . . .	Large timber, sometimes over 4 ft. in diameter. Red-brown, loose, porous, and somewhat stringy grain; soft, not tough; scented	Internal work. Well known as "Cedar of Lebanon" in ancient times; now little used.
Cedar, Deodar	*Cedrus deodara* (*Coniferæ*)	N. India . .	A very large coniferous tree; very common in N. India. Yellow to light brown; even grain; very durable	Almost all purposes in India, from bridge building and railway sleepers to delicately carved decorative work. An oil obtained from it is used as a preservative and antiseptic.
Cedar, Moulmein	*Cedrela toona* (*Meliaceæ*)	E. Indies, Australia	Colour resembles mahogany; very finely marked, straight open grain	Furniture, decorative work, veneering.
Cedar, Red .	*Juniperus virginiana* (*Cupressineæ*)	N. America.	Resembles cedar	Cabinet work, veneering.
Cedar, W. Indian (Cuban Cedar)	*Cedrela odorata* . (*Meliaceæ*)	W. Indies .	Not as large as the Cedar of Lebanon; wood much resembles the latter; often finely marked	The ordinary Cedar used in England for internal parts of cabinet work, etc.
Cherry . .	*Prunus cerasus* (*Rosaceæ*)	Europe, Asia	Yellow to light brown; hard; close grain	Ornamental work, turning.
Chestnut . .	*Castanea vulgaris* (*Cupuliferæ*)	Europe, America	Yellow to brown, fairly hard, durable	Occasionally in cabinet work; not used in carpentry and joinery; piles and fencing.
Chittagong-wood	—	—	Various ornamental woods from India—*e.g.* Moulmein Cedar (*q.v.*)	Decorative work.
Cypress . .	*Cupressus* (*Cupressineæ*)	S. Europe, Asia	Red colour; fragrant; very durable	Used chiefly by the ancients.
Deal . . .	*Pinus*	—	*See* PINE.	—
Deodar . .	*Cedrus deodara* (*Coniferæ*)	—	*See* CEDAR, DEODAR.	—

Common Names.	Botanical Name.	Localities.	Characteristics.	Uses.
Douglas Fir. (Oregon Pine)	*Pseudotsuga douglasii* (*Coniferæ*)	N.W. America	A very large tree; yellow to reddish; very hard, dense, strong; straight grain	Spars, masts; in America for building and engineering work; use increasing in England.
Ebony	*Diospiros ebenum* (*Ebenaceæ*)	India	Large tree, very dense; heart-wood very black	Ornamental work, turning, inlaying.
Elder	*Sambucus nigra* (*Caprifoliaceæ*)	Europe, etc.	Stem hollow, with a large amount of pith	Little used, except to a small extent in turning.
Elm, American	*Ulmus americana* (*Ulmaceæ*)	N. America	Tough and heavy wood	Miscellaneous uses in America.
Elm, English	*Ulmus campestris*	Europe	Brown to red; hard, heavy; difficult to work on account of the twisted grain; very durable	Piles, and other work embedded in the ground; pulley blocks, wheel hubs, shipbuilding.
Elm, Wych	*Ulmus montana*	N. Europe	Softer and straighter in grain than common elm	Chairs, shafts of vehicles.
Fir	—	—	A term applied to many timbers obtained from the *Coniferæ*. *See* LARCH, PINE, SPRUCE.	—
Fir, Silver (Swiss Pine)	*Abies pectinata* (*Coniferæ*)	S. Europe	Yellowish; very soft and easy to work	Toy making and miscellaneous uses in Switzerland; parts of musical instruments (*e.g.* bellies of violins, etc.).
Greenhart	*Nectandra rodæi* (*Lauraceæ*)	W. Indies	Green to black; heavy (*Sp. Gr.* 1·08 to 1·2), tough; very straight grain; durable	Shipbuilding, piles, wooden bridges.
Gum, Black	*Nyssa multiflora* (*Cornaceæ*)	N. America	Yellow to brown; tough, cross-grained	Miscellaneous local uses.
Gum, Blue	*Eucalyptus saligna*	Australia	Brown to red, cross-grained, heavy, durable	Sleepers, posts, building work in Australia.
Gum, Red	*Eucalyptus* (*various species*)	Australia	Red, hard, very durable	Paving and miscellaneous uses in Australia. Often confused with JARRAH (*q.v.*)
Gum, Sweet (Red Gum, Satin Walnut)	*Liquidambar styraciflua* (*Hamamelaceæ*)	United States	*See* SATIN WALNUT.	—
Gum, Tasmanian	*Eucalyptus globulus*	Tasmania, etc.	Resembles the Blue Gum, but somewhat easier to work	Uses similar to Blue Gum.
Hawthorn	*Cratægus oxyacantha* (*Rosaceæ*)	Europe, Asia	Small size; hard, heavy, light-coloured	Turnery.
Hazel	*Corylus avellana* (*Cupuliferæ*)	Europe	Small; soft, very flexible	Hoops, walking-sticks.
Hickory	*Hicoria* (*Juglandaceæ*)	N. America	Heavy, hard, very tough and elastic	Carriage building, hoops, and various work which has to withstand bending. In Australia the name is applied to other woods, *e.g.* various species of Acacia.
Holly	*Ilex aquifolium* (*Ilicineæ*)	Europe, W. Asia	Nearly white; very fine smooth grain	Ornamental work, and for engraving.
Hornbeam	*Carpinus betulus* (*Corylaceæ*)	Europe	Light colour; hard, strong	Tool handles and miscellaneous uses.
Horse-chestnut	*Æsculus hippocastanum* (*Sapindaceæ*)	Europe, Asia, N. America	Light colour; soft, not very durable.	Miscellaneous; little used in carpentry and joinery.
Ironwood	—	—	A name loosely applied to a variety of woods: *e.g.* various species of *Acacia* in Australia, and to certain members of the order *Myrtaceæ*	—
Ironwood, Black	*Olea laurifolia*	S. Africa	Large tree; very hard, durable.	Waggon building.

Common Names	Botanical Name	Localities	Characteristics	Uses
Ironwood, White	*Toddalia lanceolata*	Natal	Pale yellow colour, durable, tough	Building work in Natal.
Ironwood, White	*Sideroxylon inerme* (*Sapotaceæ*)	E Coast of Africa	Hard, heavy, and durable, yellow to red-brown	Shipbuilding and miscellaneous
Jarrah	*Eucalyptus marginata* (*Myrtaceæ*)	Australia (S W)	Large tree, colour resembles mahogany, often having a curled and handsome grain polishes well, and very durable under almost any conditions The most important of Australian woods	Wood paving, shipbuilding, general building and engineering work; the well-marked varieties are used to some extent for furniture and cabinet making
Juniper	*Juniperus communis* (*Cupressineæ*)	Europe, N Asia, and N America	Small tree light colour, soft	Miscellaneous, not important
Karri	*Eucalyptus diversicolor* (*Myrtaceæ*)	Australia (S W)	Large tree, heavy, tough, hard, durable, though inferior in this respect to Jarrah	Paving shipbuilding, and other uses similar to those of Jarrah
Kauri	*Agathis australis* (*Araucarineæ*)	New Zealand	A resinous, light-coloured straight grained wood, very durable and working well The chief timber of New Zealand, where it is often termed KAURI PINE	Masts, shipbuilding, building
Lancewood	*Guatteria virgata* (*Anonaceæ*)	S America	Straight grained tough, and elastic	Shafts of vehicles, fishing rods, and light work requiring flexibility
Larch	*Larix europæa* (*Abietineæ*)	Europe, N Asia	A large tree when fully grown, loose grained, soft wood, durable	Poles and ladders, fencing, mine timbering, piles, to some extent in general carpentry and joinery
Lignum-vitæ	*Guaiacum officinale* (*Zygophyllaceæ*)	W Indies	Dark coloured, very heavy, hard and cross grained, exceedingly durable	Miscellaneous small work, turnery etc, where hardness and freedom from splitting under rough usage are required
Lime (Linden)	*Tilia* var species (*Tiliaceæ*)	Europe	White to yellow, soft and close grained	Turnery, carving, piano making
Locust	*Hymenæa*	W Indies	Brown, hard, even grain	Shipbuilding, furniture, miscellaneous
Locust	*Robinia pseudacacia* (*Leguminosæ*)	United States Europe	Very heavy, tough, hard wood A familiar ornamental tree of small size in England, attaining a height of 70 or 80 ft in America	Fencing, turnery, cabinet work Often termed Acacia
Mahogany	*Swietenia mahagoni* (*Meliaceæ*)	W Indies, Central America	Hard, close grain grain straight but often showing a wavy or curly figure, characteristic reddish brown colour Very durable, free from shakes and not liable to warping Can be obtained in very large logs, in some cases over 4 ft square	Furniture cabinet making, veneers, turnery, high-class internal joinery and fittings
Maple	*Acer* (*Acerineæ*)	Europe, North Asia	Light brown or reddish, often showing a curled or mottled figure, whence the name "Bird's Eye Maple	Turnery, veneers, various cabinet and ornamental work
Mulberry	*Morus alba* (*Moraceæ*)	Europe, Asia	Yellow to mahogany-red, hard, close grained	Veneering and ornamental work
Myrtle (Spurious)	—	—	The name is applied in Australia to a number of woods of small importance, none of these are true myrtles.	—

Common Names.	Botanical Name.	Localities.	Characteristics.	Uses.
Oak . . .	*Quercus* (*Cupuliferæ*)	Northern Hemisphere	The most important of all hard woods. Colour light greyish yellow to dark brown. Hard; very strong grain, often showing a handsome figure, that obtained by cutting a log in a radial direction being termed the "Silver Grain." Very durable; capable of taking a high polish	Heavy work requiring great strength and durability: piles, shipbuilding, building work, especially such parts as are exposed to the weather, furniture, and a great variety of other uses.
Olive . . .	*Olea Europæa* (*Oleaceæ*)	S. Europe .	Very close-grained, yellowish, somewhat resembling Box	Turnery and small articles.
Padouk . .	*Pterocarpus* (*Leguminosæ*)	S.E. Asia .	Hard, heavy, dark red, somewhat like mahogany; not attacked by insects	Furniture and miscellaneous uses in India and Burma.
Peach . . .	*Amygdalus persica* (*Rosaceæ*)	—	—	Widely distributed; little used as timber.
Peach-wood .	*Cæsalpina* (*Leguminosæ*)	S. America .	Small tree; hard heavy wood	Source of a dye.
Pear . . .	*Pyrus communis* (*Rosaceæ*)	Europe, Asia	Even grain, fairly hard; colour light brown; durable	Turnery, T-squares and set-squares, occasionally for cabinet work.
Pine . . .	*Pinus* (*Coniferæ*)	Northern Hemisphere	The general name Pine is given to a great number of woods obtained from trees of the order *Coniferæ*; to certain of these the names Deal and Fir are applied. The wood is resinous, usually fairly soft, straight-grained, and easy to work	Building work, and a great variety of miscellaneous carpentry and joinery.
Pine, Kauri .	—	—	*See* KAURI.	—
Pine, Long-leaf	*Pinus palustris* .	N. America .	The PITCH PINE of commerce. One of the harder varieties of pine; very resinous; strongly marked grain, often showing a very fine figure; durable	Building, furniture, spars, shipbuilding.
Pine, Northern	*Pinus sylvestris* .	N. Europe and N. Asia. The Baltic regions are the chief source	SCOTCH FIR, RED or YELLOW DEAL; includes much of the FIR of commerce. Yellow to slightly reddish; straight-grained, and obtainable in long logs. Somewhat variable, according to locality and conditions of growth	Building, spars, etc.; a vast amount of general carpentry and joinery. It is the most important wood used in this country.
Pine, Oregon	*Pseudotsuga* . .	N.W. America	The DOUGLAS PINE or FIR. Very similar in character to Larch; straight-grained; yellow to reddish, usually darker than Northern Pine; can be obtained in very long logs	Masts and spars, general building work in America, and now coming rapidly into use in England.
Pine, Pitch .	—	—	*See* PINE, LONG-LEAF.	—
Pine, Red .	*Pinus resinosa* .	N. America .	CANADIAN RED PINE. Hard, tough, reddish; contains much resin, and is very durable	Spars, building.
Pine, Swiss .	*Abies pectinata* .	Central Europe	Light, soft; very little resin; easily worked	Piano soundboards, violin bellies, miscellaneous purposes.
Pine, White .	*Pinus strobus* . .	N. America .	Also known as Yellow Pine. Soft, straight-grained; does not contain resin	Building and miscellaneous uses, especially in America.
Plane, Eastern	*Platanus orientalis* (*Platanaceæ*)	Asia and E. Europe	Yellow to brown; fine close grain, but not durable	Miscellaneous uses; not very important in England.

Common Names.	Botanical Name.	Localities.	Characteristics.	Uses.
Plane, Western	*Platanus occidentalis*	N. America.	Resembles the above, but coarser and more cross-grained	Furniture, veneers, and miscellaneous uses.
Plum . . .	*Prunus domestica* (*Rosaceæ*)	Europe, Asia, etc.	Yellow to brown, hard, not durable	Turnery, cabinet work.
Poplar . .	*Populus* (*Salicineæ*)	Europe, Asia	Soft, light colour, not liable to split	Turnery, paper-pulp, charcoal.
Redwood . .	—	—	A name applied to various woods—*e.g.* a variety of Eucalyptus in Australia, and to Northern Pine (*q.v.*)	—
Redwood, Californian	*Sequoia* . . .	West of N. America	Orange to red; soft, not strong, but withstands the action of soil; easily split. Known in England as *Sequoia*	Building and general purposes in California; used in England for furniture.
Rosewood .	—	—	A variety of woods of dark colour are known by this name. None of them belong to the Rose family.	—
Rosewood, Brazilian	*Dalbergia* (*Leguminosæ*)	America .	Dark brown to red, open-grained, heavy	Cabinet making, turnery, and ornamental work.
Sandalwood .	*Santalum* (*Santalaceæ*)	S. Asia . .	Yellow, fragrant, hard wood	Ornamental work, and as a source of sandalwood oil.
Satin Walnut	*Liquidambar styraciflua* (*Hamamelaceæ*)	East of U.S.A.	Reddish brown, soft, close grain; easy to work, polishes well, but very liable to shrinkage and warping	Much used for the cheaper varieties of polished cabinet work and furniture.
Satinwood .	*Chloroxylon* (*Meliaceæ*)	S. India . .	Orange yellow, finely marked, polishes well, fairly durable	Ornamental work.
Sequoia . .	—	—	*See* REDWOOD.	—
Spruce . .	*Picea excelsa* (*Coniferæ*)	N. of Europe, Asia, and America	WHITE DEAL, SPRUCE FIR, WHITE FIR. White to yellowish, soft, straight grain; easy to work, but apt to warp	Poles and spars, flooring, general carpentry; also as a source of wood-pulp, charcoal, and resin.
Sycamore . .	*Acer pseudo-platanus* (*Acerineæ*)	Europe and W. Asia	Very white, soft, easily worked, polishes well; durable if not exposed to damp	Turnery, carved work, cabinet work, violin making, and miscellaneous uses.
Teak . . .	*Tectona grandis* (*Verbenaceæ*)	S. Asia . .	Brownish red, hard, tough, often finely marked, very fragrant. It is somewhat difficult to work on account of particles of mineral matter; extremely durable, probably more so than any other timber	Shipbuilding, heavy timber work.
Tulip Tree .	—	—	*See* WHITEWOOD.	—
Tulip-wood .	*Harpullia pendula* (*Sapindaceæ*)	Australia .	Black and yellow markings; tough and strong (The name Tulip-wood is also applied to two or three other ornamental woods of less importance)	Ornamental cabinet work.
Walnut . .	*Juglans regia* (*Juglandaceæ*)	Europe, Asia	Light to very dark brown, often finely marked; strong, hard, durable; polishes well	Cabinet making, furniture, veneers, turnery, gunstocks.
Walnut, Satin	—	—	*See* SATIN WALNUT.	
White Deal .	—	—	*See* SPRUCE.	—
Whitewood .	*Liriodendron tulipifera* (*Magnoliaceæ*)	N. America.	White, slightly tinged with yellow; very soft and easily worked; fairly durable, but liable to shrinkage; takes stains and polishes well. Can be obtained in large logs and wide boards, very free from knots	Building work, cabinet making, carriage building, and general joinery. Rapidly becoming a very important wood in this country.

Common Names.	Botanical Name.	Localities.	Characteristics.	Uses.
Willow . .	*Salix* (*various species*)	Europe, N. America	White, soft, smooth grain; very little tendency to split or splinter; withstands the action of water well	Floats of water-wheels, etc.; brake blocks, small carving, and toys, cricket bats; wood-pulp, charcoal. Thin shoots are used extensively for basket work, hurdles, etc.
Yew . . .	*Taxus baccata* (*Taxineæ*)	Europe, Asia, N. Africa	Reddish, very hard, tough, flexible	Chairs, turnery, walking-sticks, etc. Formerly used for archers' bows.

Wood Screw. A screw (*q.v.*) of conical form, having a V-thread of coarse pitch but small thickness, and a point by which it is enabled to penetrate wood. Usually made of steel or brass.

Wood Sleepers (*Civil Eng.*) In Europe sleepers are usually of Baltic pine, soaked in creosote. Hard woods are, however, preferable where they can be obtained cheaply, and in America certain varieties of oak have been largely used. *See* RAILWAYS.

Wood Spirit (*Chem.*) A mixture of methyl alcohol, acetone, allyl alcohol, and a number of other substances present in smaller quantities. It is largely used in the preparation of methylated spirit, which contains 10 per cent. The method of obtaining it is given under methyl alcohol (*q.v.*) *See also* TAR.

Wood Tin (*Min.*) *See* CASSITERITE.

Wood Turning. Wood is still in the majority of cases turned by means of hand tools, though the lathe itself is usually driven by power in large shops. For soft wood, gouges and chisels with acute cutting edges are the principal tools used; for hard woods, tools with more obtuse edges, resembling those used in brass turning, are employed. In special cases a slide rest may be used, and in certain kinds of repetition work automatic lathes are of great value. *See also* LATHE *and* TURNING TOOLS.

Woodwardite (*Min.*) A hydrous sulphate of copper and alumina, found in Cornwall. It occurs as a brilliant turquoise blue incrustation with a rippled surface.

Wood Wind (*Music*). A term applied to the group comprising the flutes, oboes, clarionets, and bassoons in the orchestra.

Woodworking Machines. A great variety of machines are employed for woodworking on a large scale. PLANING MACHINES are of two classes. In the larger class, cutting tools are mounted upon a revolving block (ADZE BLOCK) or disc, which is caused to rotate at a high speed while the wood travels past the cutter. In the other form the cutter resembles a plane iron, and is fixed in position, while the wood is moved past it in a manner analogous to the planing machines used for metal. MOULDING MACHINES have a revolving head, or cutter block, carrying suitably shaped cutters. Other machines include various forms of LATHE, machines for MORTISING, BORING, DOVETAILING, SANDPAPERING, and various special purposes. Many forms of saw are used, of which the principal types are given on p. 643.

Woof (*Weaving*). *See* WEFT.

Wool, Woollen, and Worsted Manufacture. The manufacture of woollen cloth is one of the oldest of the national industries. Historical evidence shows that the carding and spinning of wool and the weaving of woollen yarns was practised by the Romans, and it is probable that these arts were fostered at Winchester and other places in the south. The industry received a stimulus during the persecution of the Huguenots and the importation of the Flemish weavers into this country in the sixteenth century. Still, up to the end of the eighteenth century the manufacture of all classes of fabrics was chiefly a manual process. The transformation from this period to that in which machinery was gradually invented and applied to almost every branch of textile production occurred between the last decade of the eighteenth century and the first three decades of the nineteenth. Like many other industries, the manufacture of woollen and worsted fabrics has been greatly influenced by mechanical inventions. The more important of these have been originated and perfected by British manufacturers and machinists. The Carding machine, Spinning frame, Power loom, and the mechanism for finishing and pressing the cloth after weaving, have all been English or Scotch inventions. Since 1875 Germany, France, Belgium, and America have made rapid progress in the construction and building of textile machines. In the woollen and worsted industry, however, the machinery of English makers is still in high repute on the Continent, and is almost solely used in the mills of the United Kingdom. In other words, whilst machinery constructed in this country is exported to the woollen and worsted centres on the Continent, that of German and French firms, with the exception of milling machinery and one or two types of finishing machines, has failed to obtain a place in British factories, and even these have only been used to a small extent. WOOLLENS AND WORSTEDS: The trade in fabrics made of wool is divisible into two sections, termed woollen and worsted respectively. To the uninitiated the difference is not obvious, especially when it is considered that the same variety of wool, and the same quality, may be used in both manufactures, but with totally different results. The early distinction was that a longer staple of wool was required in making *worsted* yarns; but the invention of Noble's combing machine, and the many improvements added to its construction, have removed the cause for this differentiation, and it is now feasible to deal with wool of a comparatively short staple on the worsted, as well as on the woollen system of yarn manufacture. The grading of the material into woollen and worsted is due to the routine of yarn manufacture practised. Briefly defined, the blending, carding, and spinning machinery for treating wool in making

a WOOLLEN YARN results in all kinds of fibres—curly, short, and of various lengths—entering into the spun thread. Moreover, these fibres, which in carding undergo a certain measure of combing or straightening between the wire teeth of the card clothing on the cylinders, are recrossed and blended without any attempt at parallelisation. As regards WORSTED YARN, on whatever system it may be made, and even though carding may form one of the processes, the chief object is to bring the fibres as far as possible into a line with each other by combing, etc. Another element which accentuates the difference between the two threads is that in the combing process a quantity of the short, neppy fibre is extracted, so that only the straighter and longer fibre passes into the top, and subsequently into the roving and the yarn. A comparison of the condition of the materials of these two typical threads, when carded and combed, shows that the fleece of fibres in both instances possesses uniform density and adhesiveness; but in all other points it differs. In the *carded state* the fibres are crossed in every conceivable way, but in the *combed state* they are straight and parallel. The top (combed wool) when opened out is found to be very free from curly and neppy clusters of small fibres, and subsequent processes further level and straighten the ribbon of fibres, which attain a degree of parallelism that would appear impossible by mechanical routine when the matted, felted, natural state of the wool is considered. It is, therefore, the YARN STRUCTURE which forms the distinction between woollen and worsted fabrics. The processes of weaving and finishing through which each yarn passes do not necessarily bring about any differentiation between the fabrics produced. That is to say, if the wool were treated on the woollen and worsted principles, and made into yarns of similar counts or diameters, and each made into the same build or structure of fabric and submitted to similar finishing routine, yet the woven textures would in character be very distinct from each other. The WOOLLEN CLOTH would be denser, warmer in the wear, and apparently the closer structure. This arises from not having removed any of the short fibre from the staple of the wool. On the other hand, the WORSTED would be smarter, brighter, and have a better appearance. There are more points of resistance to the friction of wear on the surface of a woollen than on a worsted cloth, and this is one of the chief reasons why the worsted has a greater tendency to become shiny or bright wherever it is subjected to friction. These general characteristics apply to all kinds of woollen and worsted cloths for whatever purpose manufactured. Woollen cloths are made in all weights from 7 or 8 oz. up to 32, 34, and even 36 oz. per yard (54 and 56-in. wide) for the heavier types of overcoatings. There is not the same diversity of weight in worsteds. Fashion has removed the great lines of demarcation between fabrics for men's and women's wear. Only a few years ago the dress trade was distinctly an alpaca or mohair manufacture. Such fabrics are still produced, but are now largely substituted by woollen and worsted costume cloths of Cheviot, Saxony, crossbread, and Botany yarns.

Routine of Manufacture for Woollens.—This can only be very briefly summarised. The wool, in the first place, is sorted or classified as to quality. It is naturally in a greasy condition, the ordinary English crossbred wool averaging 25 to 35 per cent. of greasy matter; but the fine merino wools, such as Saxony, Australian, and New Zealand, as much as 60 per cent. and more. This is removed by scouring in large tanks or bowls, usually three or four in number, after which the wool is passed through a machine known as the teazer, which separates the matted locks of fibres and prepares it for carding. Should the material be for coloured yarns, after scouring the wool is dyed, in which case teazing both disentangles the locks of wool and blends the colours together, producing a mixture. It is now carded. CARDING consists of passing the wool between fine wire teeth on a series of large cylinders. Over these are a number of smaller rollers similarly covered, the function of which is, first, to impede the forward progress of the wool, and, second, in conjunction with each other and the quickly revolving cylinder, to fully open out the staple, ultimately separating fibre from fibre. At the same time, re-blending or re-crossing of the filaments continues. The work is, therefore, twofold in character: first, to dislocate the natural positions of the fibres in relation to each other; and, second, to re-cross, mix, and work them into a fleece of continuous length and similar density throughout. Attached to the last cylinder of the carder is what is termed a condenser, which removes the fleece from the cylinder, and then divides it into narrow strips which may be rubbed or rolled into thick, soft threads. SPINNING: These are taken to the spinning frame, known as the Mule Jenny, and spun into yarn. The process consists in intermittently delivering lengths of the condensed thread or sliver from large bobbins by passing them between a pair of rollers and attaching them to spindles fixed in a carriage or frame travelling alternately to and from the fixed rollers. Lengths of sliver are, first, delivered whilst the carriage makes a portion of the outward traverse, the spindles at the same time revolving. The rollers cease to turn, but the carriage continues its movement, and the speed of the spindles is increased. During this period drafting or attenuation of the thread is effected as twist is inserted. The carriage having reached the termination of its traverse, the spindles continue to revolve for the final twisting. As the carriage reverses its traverse, the threads are held in a suitable position to be wound in a conical form on the spindle. WEAVING is the next operation, and is the same in principle in both woollen and worsted fabrics. The yarns are first warped or arranged after a prescribed pattern and length, and wound on to the loom roll or beam. Before weaving can be accomplished the threads are drawn through small metal eyes of the heald shafts or heddles. These shafts rise and fall when the loom is in operation, each lifting or depressing a series of threads in the warp, making a division termed the "shed." The shuttle carrying the weft passes between the lifted and depressed yarns. For each pick or thread of weft conveyed by the shuttle the healds change positions. The weaving of a piece of cloth is the repetition of a certain series of changes, according to the number of picks in each round of the weave or design. The yarns which form the length of the cloth are, therefore, complete at the beginning of weaving; but the weft is added thread by thread, forming a woven piece. The routine after weaving consists of scouring, milling, or felting, and in some instances raising—that is, covering the cloth with fibre, cutting, removing the surface fibre, and pressing.

Routine of Worsted Yarn Manufacture.—The worsted industry consists of two distinct sections: (*a*) The manufacture of the yarn and (*b*) the manufacture

and finishing of the fabric. In this respect it differs from the woollen industry, which is usually carried on throughout the whole range of manufacturing in one factory. This departmental division has, in a measure, contributed to the success of this important branch of the all wool industry. A section of the trade has thus been confined to producing economically every variety of yarn, and another section to the manufacture of the woven texture. Consider first the PRODUCTION OF THE YARN. There are three distinct methods: (*a*) By the processes of carding, combing, gilling, drawing, roving, and spinning, resulting in the fine Botany and also crossbred yarns used in the manufacture of worsted coatings, suitings, trouserings, and costume fabrics. (*b*) For long wools, preparing by gilling and following with a similar series of operations. (*c*) The first routine, with the exception of combing. This produces a yarn which has some of the qualities of a worsted and some of a woollen thread, and is suitable for Scotch and Kidder carpets. COMBING is the process by which the carded or gilled wool is straightened, and the fibres laid in one common line. This is done by forcibly drawing the wool between fine teeth, and delivering it in a continuous ribbon of fibres, known as *top*. Part of the work also consists in extracting short, curly fibre, which is termed the "noil," so that the top is free from much of that neppy filament which is seen in the carded wool. The machines on which the work is done are known as the Noble, the Square Motion, and the Nip Combs. Whilst very different in construction and working, the results acquired are similar. GILLING is performed in the gill boxes, which possess two pairs of rollers, front and back, revolving at different speeds. Between these are placed the fallers, iron bars studded with fine vertical teeth, and which travel from the front to the back rollers at a higher speed than the feed rollers, but slower than the delivery rollers. Reaching the end of the forward traverse, they drop on to a lower screw, and are conveyed back to the front rollers, and replaced on the upper screw. The wool passing between the first pair of rollers is drawn between the teeth of the fallers by the delivery rollers. In other words, there is a drafting or drawing out of the wool at two points by the fallers from the front rollers, and by the delivery rollers from the fallers. The fibres of wool are thereby further straightened and parallelised. DRAWING: In the first drawing boxes a similar process continues as in gilling, several ribbons of wool being drawn out to the thickness of one. In the finishing drawing boxes the fallers and gill pins are not used, but several thick ribbons of fibres are combined and attenuated to the thickness of one, and further reduced in size at each box, and wound on to smaller bobbins each time, until the roving box is reached, where the material begins to assume the form of a thread, which by twist can be converted into a fine weavable yarn. SPINNING: This is different from the operation performed on the mule spinning frame used in making woollen yarn. It is on what is known as the "continuous" system; that is to say, the thread is continuously delivered and spun, not intermittently. The rovings pass between two pairs of rollers revolving at various speeds, where further drafting takes place, and are spun into yarn on three systems. First, the Flyer, which is similar in principle to the distaff or single spinning wheel, only the spindle and flyer are in a vertical instead of a horizontal position and duplicated a large number of times. Second, on the Cap Frame, where the bobbin is covered with a metal cap and the thread rapidly revolves round the lower rim of the same as it is spun and wound on to the bobbin. Third, on the Ring Frame, in which a small ring or "traveller" is placed on a metal rim and guides the thread during spinning on to the bobbin. WEAVING: The industry is divided into the spinning and weaving of (*a*) Long wools, such as those grown in Leicestershire and Lincolnshire, suitable for dress and mantle fabrics; (*b*) Crossbred, a coarse stapled wool, such as that grown in many parts of Great Britain and Ireland, and also largely imported from the Colonies and made into serges and dress fabrics; (*c*) fine wools of the Botany type, principally from Australia, the Cape, and South America, and which are used in the medium and finest qualities of worsted fabrics. Worsted fabrics comprise a very wide range of woven productions. Broadly speaking, they may be classified under two heads, namely, PIECE DYE and FANCIES. As the term suggests, the former are dyed in the piece, and are usually coatings, suitings, and costume cloths. Fancies are top or yarn dyed; that is to say, the pieces are made of yarns in which the material has either been dyed after combing or after it has been spun into the yarn, the first being the most usual practice. Fancies, in addition to the fabrics named under piece dyes, also include many varieties of dress and blouse materials, vestings, trouserings, and covert coatings, all of which are capable of many subdivisions. *A feature about worsted fabrics, as distinguished from the woollen, is the diversity of weave design obtainable.* It follows that they are richer in technical weave effects, and also clearer in colour than the patterns produced in woollen yarns. Many Scotch tweed manufacturers, whose trade was formerly confined to suiting cloths, or what may be more correctly defined "men's" fabrics, now run in the same mill many varieties of textures for costumes, vestings, suitings, etc. The worsted trade is more departmental, one cause being that a much lighter construction of loom, and one capable of a higher speed is employed, being better adapted for the weaving of worsted dress and costume fabrics than the loom used in the suiting and trousering trade. The chief centres of the different branches of the industry are: For the FINE WORSTED TRADE: Huddersfield, Leeds, Bradford, Halifax, and the west of England, though some worsted manufacturing is also done in the border towns of Scotland and in the south of Ireland. The TWEED industry is chiefly located in the south of Scotland and Wales; a medium quality of tweed is also made in the West Riding of Yorkshire. Fine SAXONY CLOTHS are produced in the west of England and the West Riding of Yorkshire; FLANNELS in Yorkshire and Wales; BLANKETS AND RUGS in the Dewsbury and Sowerby Bridge districts; and the low woollen industry for ready made clothing is carried on in the West Riding at Batley, Dewsbury, Morley, etc. It should, however, be observed that these divisions are not always strictly adhered to, as there are some mills engaged upon fancy woollens, fine worsteds, and serges in each of these centres.—R. B.

Woollen Blanket. *See* BLANKET.

Wool Scarlet. *See* DYES AND DYEING.

Woolwich and Reading Beds (*Geol.*) The middle division of the Lower London Tertiaries. *See* STRATA, TABLE OF (in Appendix).

Worcester (*Pottery*). The Worcester porcelain works were established in 1751, by Dr. Wall, of Worcester. In 1783 the business was purchased by

Mr. Flight, and subsequently passed through the following periods: 1793, Flight & Barr; 1807, Barr, Flight & Barr; 1813, Flight, Barr & Barr. In 1840 the manufactory was united with that of Messrs. Chamberlain, a rival factory in Worcester. The manufactory is carried on by the present Royal Porcelain Company, and it is the only Porcelain Works in England with an unbroken record of more than 150 years. Worcester has been noted for producing a greater variety of designs, etc., than any other porcelain manufactory, commencing with simple blue and white wares, up to services and vases decorated, painted, and gilt in the most costly manner, combined with judgment and taste.

Work (*Mech.*) If a force be so applied as to overcome a resistance and produce motion, it is said to do Work. The measure of the work done is the product of the force into the displacement which it effects. If a force of one Dyne act through a distance of one centimetre, the amount of work done is termed one ERG. If a force of one poundal act through one foot, the work done is one FOOT POUNDAL. If a force equal to the weight of one pound act through a distance of one foot, the work done is one FOOT POUND. The latter is the English engineer's unit of work.

Working (*Mining*). A general term used either for a mine as a whole or for some part thereof, *e.g.* a level, drift, stope, etc.

Working Cylinder (*Eng.*) The cylinder of a gas engine, etc., in which the actual explosion occurs, as distinguished from a separate cylinder used for the purpose of compressing the charge.

Working Drawing. A drawing showing the details and dimensions necessary for workmen engaged in the construction of the object in question.

Working Face (*Mining*). The surface which is actually being excavated.

Working Fat (*Plast.*) A term used by plasterers to indicate that the plaster works smoothly (with less labour).

Working Load (*Eng., etc.*) The load to which a machine or structure is subjected in ordinary use.

Worm (*Eng.*) A coarsely cut screw, usually engaging with a WORM WHEEL (*q.v.*)

Worm Wheel (*Eng.*) A form of gear wheel whose teeth are cut in such a form that they engage smoothly with a worm or coarse threaded screw. The latter has in general its axis at right angles to the wheel, which it drives.

Worsted Manufacture. *See* WOOL.

Wraithe (*Textiles*). A coarse reed or comb (which will expand or contract), used in the beaming or warping processes.

Wrapping Papers. These are prepared from chemical wood pulp, jute, or manilla.

Wrench (*Eng., etc.*) A SPANNER (*q.v.*), usually having adjustable jaws.

Writing *or* **Printing Telegraph.** *See* TELEGRAPHY.

Wrong Fount (*Typog.*) Letters of a different "face," though of the same body. *See p.* 566, EXPLANATIONS.

Wrong Gait (*Lace Manufac.*) When a carriage becomes diverted from its true course and is forced into an adjoining groove or comb that is already occupied.

Wrought Iron (*Met.*) *See* IRON.

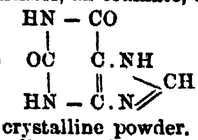
Wulfenite (*Min.*) Molybdate of lead, $PbMO_4$. Tetragonal; yellow to brown. Scotland and Central Europe.

Wyvern, Wivern (*Her.*) An imaginary beast, a species of dragon but having only two legs and feet or claws. It has also two wings, and a tail like a serpent "nowed" and "barbed."

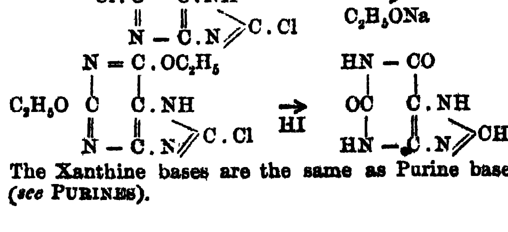
X Rays. Röntgen Rays: *see* RADIATION, *p.* 592.

x. The symbol used in mathematics for an unknown quantity, a variable, an ordinate, etc.

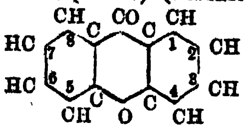
Xanthine (*Chem.*)

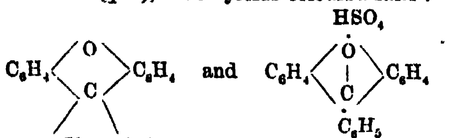


(2:6-dioxypurine). Ordinarily forms a crystalline powder. It can be obtained in very small rhombic plates by addition of acetic acid to a hot dilute alkaline solution. It sublimes without melting, but with decomposition. Very slightly soluble in water (about 1 in 14,000), more soluble on boiling, insoluble in alcohol. As a weak base it forms salts with strong acids, and the salts are hydrolysed by water. As a weak acid it dissolves more readily in alkalis (ammonia, caustic potash) than it does in water, forming salts with them. Its lead salt yields theobromine (*q.v.*) with methyl iodide. Xanthine is precipitated from its solutions both by phosphotungstic and phosphomolybdic acids; it is also precipitated by mercuric chloride solution. It forms a salt with silver nitrate, $C_5H_4N_4O_2AgNO_3$, when a solution of its nitrate is precipitated with silver nitrate. When dissolved by warming in fresh chlorine water, evaporated to dryness, and the residue exposed to ammonia gas under a bell jar, it gives a rose to purple red colour, which changes to blue violet on adding caustic soda (Weidel's test); dissolved in hot nitric acid and evaporated it gives a yellow residue (whence the name Xanthine), which is turned to orange by caustic soda. Xanthine occurs in normal urine in traces (Krüger and Salomon obtained 13 grams from 10,000 litres of human urine); in larger amount in certain diseases. It is formed by the self-digestion of several organs of the body—liver, thymus, suprarenal; also by the self-digestion of yeast. It is also found in several foods (tea, malt), in lupin seeds and pumpkin seeds. It is obtained from guanine by the action of nitrous acid. It has been synthesised as follows: 2:6:8-trichlorpurine (*see* PURINES) is heated with excess of sodium ethoxide at 100°, when 2:6-diethoxy-8-chlorpurine is obtained. This compound may be hydrolysed by boiling with hydrochloric acid, and the product reduced with hydriodic acid, or it may be reduced with hydriodic acid:

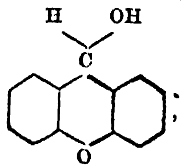


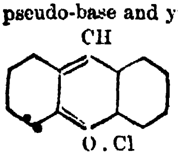
The Xanthine bases are the same as Purine bases (*see* PURINES).

Xanthones (*Chem.*) (Dibenzopyrones.) Xanthone itself,  , is a white crystalline solid (needles); melts at 174°; boils at 250°; insoluble in water; sparingly soluble in alcohol; more soluble in benzene; dissolves in concentrated sulphuric acid, showing a blue fluorescence. Fused with caustic potash at 200° it yields orthodioxybenzophenone, $CO(C_6H_4OH)_2$. It does not yield a hydrazone or oxime. On treating it with magnesium phenylbromide and hydrolysing the product it yields a pseudo-base (*q.v.*), which yields coloured salts :



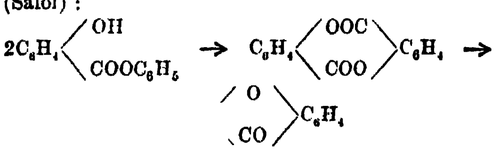
Pseudo-base. Coloured Sulphate (Quadrivalent oxygen).

On reduction with zinc dust xanthone yields xanthhydrol,  , which is also a pseudo-base and yields coloured salts with acids, *e.g.*



Hydrochloride. (Quadrivalent oxygen.)

Xanthone is obtained by distilling phenylatecylate (Salol) :



It is also obtained by heating salicylic acid with acetic anhydride, the reaction being quite similar to the above, salicylide being formed first. Euxanthone is 1 : 7-dioxyxanthone—a yellow solid crystallising in needles and melting and subliming at 237°. It occurs in the pigment Indian yellow (*q.v.*), which is the magnesium salt of euxanthic acid. Euxanthic acid is a compound of euxanthone and glycuronic acid. The pigment is obtained as a deposit by heating the urine of cows which have been fed on mango leaves (Bengal). To obtain euxanthone from the pigment it is exhausted with water, then with dilute hydrochloric acid, and the residue extracted with ammonium carbonate. From the ammonium salt hydrochloric acid precipitates euxanthic acid, which on hydrolysis with dilute sulphuric acid yields euxanthone and glycuronic acid.

Xanthoproteic Reaction (*Chem.*) A test for proteid substances depending on the production of a yellow colour when the substance is heated with strong nitric acid (the reaction may occur without heating) which is intensified on addition of ammonia. The colour depends on the formation of aromatic nitro-compounds such as picric acid. A common instance of the test is seen when nitric acid gets on to the hands.

Xanthorrhea (*Botany*). A genus of the *Liliaceæ*. *X. hastilis*, the Australian grass tree, yields a resin used in the manufacture of sealing wax and varnish.

Xanthosiderite (*Min.*) Hydrous ferric oxide, $Fe_2O_3 . 2H_2O$, containing 57 per cent. iron. It occurs usually in fibrous masses of a yellow brown colour. From the Harz, Ireland, etc.

Xe (*Chem.*) The symbol for XENON (*q.v.*)

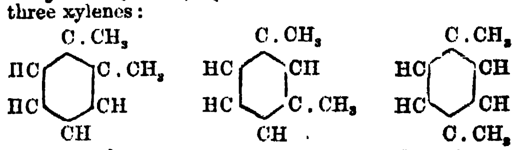
Xenon (*Chem.*) Xe. Atomic weight, 128. A colourless gas; boils at − 109°; it is a solid at the temperature of liquid air; has a monatomic molecule; no reactions. It occurs to the extent of about 1 volume in 20,000,000 volumes of air, and is obtained from the less volatile portion of liquid air (after removing the remaining oxygen and nitrogen) by fractional distillation. It has a characteristic spectrum containing many green lines.

Xerophyte (*Botany*). A plant modified for reduction of transpiration, owing to conditions in the soil preventing the normal absorption of water by the roots. Xerophytes are characterised by leathery leaves, thick cuticle, sunken stomata, etc.

Xoanon (*Archæol.*) The term applied to a primitive kind of statue, supposed to be the result of superhuman work, and revered accordingly.

Xylem (*Botany*). The term applied to the wood of plants. It consists of wood vessels and tracheides—two forms of water-conducting tissue—and a variable amount of wood fibres for support. *Cf.* PHLOEM.

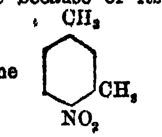
Xylenes (*Chem.*) (Dimethylbenzenes). There are three xylenes :



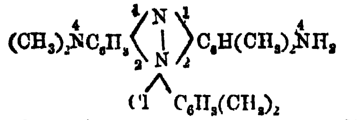
Orthoxylene.	Metaxylene.	Paraxylene.
M.P. − 28°	M.P. − 54°	M.P. + 15°
B.P. 142°	B.P. 139°	B.P. 138°

They all occur in coal tar, but metaxylene to a far greater extent than the others; thus commercial xylene from coal tar contains from 70 to 87 per cent. metaxylene. They can all be obtained by the general methods for obtaining benzene homologues, *viz.* (1) Fittig's reaction (*q.v.*); (2) Friedel and Craft's reaction (*q.v.*); (3) by distilling the sodium salts of suitable carboxylic acids with soda lime, *e.g.* metaxylene from mesitylenic acid. *See* MESITYLENE. They are all colourless liquids, smelling like benzene; insoluble in water. When boiled with dilute nitric acid the orthoxylene yields orthotoluic acid; the metaxylene is only slightly attacked; the paraxylene yields paratoluic acid. On further action of nitric acid the ortho- and para-compounds yield the corresponding dicarboxylic acids. Boiled with potassium permanganate they behave in the same way as with dilute nitric acid. Chromic acid oxidises orthoxylene completely to carbon dioxide and water, the other two to the corresponding dicar-

boxylic acids. The most important of the three xylenes is metaxylene, which can be separated from commercial xylene by boiling with diluted nitric acid, distilling the product in steam, shaking the distillate with caustic soda to remove acids, drying, and distilling over the metaxylene. Metaxylene is important because of its use in making dyes. A nitroxylene



can be prepared from it in the usual way. *See* NITRO-COMPOUNDS. This nitro-metaxylene on reduction (iron and hydrochloric acid) yields metaxylidine. Metaxylene also sulphonates like benzene, but it yields two isomeric sulphonic acids. Examples of dyes prepared with the use of xylene derivatives are: Methylene violet,



which is obtained by the action of nitrosodimethylaniline hydrochloride upon the hydrochloride of metaxylidine (and some paraxylidine). A number of scarlet dyes are derived from metaxylidine; *e.g.* Ponceau 2 R or Xylidine scarlet.

$$C_6H_3(CH_3)_2N \cdot \overset{1}{N} \cdot C_{10}H^4 \begin{cases} OH(2) \\ SO_2ONa(3) \\ SO_2ONa(6) \end{cases}$$

which is obtained by the action of β-naphtholdisulphonic acid R on a diazosalt of metaxylidine.

Xylidine (*Chem.*) *See* XYLENES.

Xylography. (1) Wood engraving: *see p.* 202; (2) Printing from engraved wood blocks.

Xylometer. An instrument for taking certain measurements in determining the specific gravity of woods.

Xylonite. A form of CELLULOID (*q.v.*)

Xylophone (*Music*). A musical instrument consisting of graduated blocks of resonant wood, which are struck by two small hammers.

Xylose (*Chem.*)

$$\begin{array}{c} CH_2OH \\ | \\ H.C.OH \\ | \\ HO.C.H \\ | \\ H.C.OH \\ | \\ CHO \end{array}$$

A five carbon atom sugar (pentose). Crystallises in white needles; melts about 145°; readily soluble in water and in hot alcohol; tastes sweet; is dextrorotatory and shows multi-rotation. On reduction it yields the corresponding alcohol, and on oxidation with bromine water it yields a monocarboxylic acid. On oxidation with nitric acid it yields a dicarboxylic acid—trioxyglutaric acid. It gives a tetra-acetate with acetic anhydride, and sodium acetate and an osazone with phenylhydrazine. Xylose does not undergo the alcoholic fermentation. It has been synthesised, and is known in the lævo- and inactive forms. Xylose is a splitting product of certain nucleo proteids, and so occurs in various organs of the body; it is also occasionally found in urine. It is a product of the hydrolysis of wood gum, but the wood gum need not be prepared first; thus it can be obtained from chopped wheat straw by first digesting with dilute ammonia, then hydrolysing with dilute sulphuric acid, and in a similar manner from brewery grains. *See also* SUGARS *and* OSAZONES.

Xyst *or* **Xystus** (*Architect.*) In classical architecture, a covered portico or other place in which athletes exercised.

Y (*Chem.*) The symbol for Yttrium (*q.v.*)

Y Level (*Surveying*). A level so called because the telescope is mounted on forked rests called "Y's," from which it can be lifted and reversed. A form of theodolite is called the "Y Theodolite" for a similar reason.

Y Theodolite (*Surveying*). *See* Y LEVEL.

Yak. A Tibetan species of ox (*Bos grunniens*), used as a beast of burden. The milk is of good quality, and the long silky hair is woven into ropes.

Yam (*Botany*). The plants of the genus *Dioscorea* (order, *Dioscoreaceæ*), are characterised by having large underground tubers of a starchy nature, used in the tropics for food.

Yarn (*Textile Manufac.*) A general term for the spun thread prepared for the weaver, either warp or weft. The yarn is defined as soft spun, medium spun, hard spun, according to the amount of twist it has received. *See* WARP *and* WEFT.

Yarn Counts (*Textile Manufac.*) The fixed length or weight for determining the counts, size, or diameter of a yarn. *See* COUNTS.

Yarn Testing (*Textile Manufac.*) Yarns are tested by special apparatus for twine, breaking strain, and elasticity.

Yaryan (*Paper Manufac.*) The term applied to an apparatus used for evaporating spent liquor to a small bulk.

Yataghan (*Arms*). A Turkish sword with the blade doubly curved, and the handle devoid of guard.

Yb (*Chem.*) The symbol for YTTERBIUM (*q.v.*)

Year, Civil (*Astron.*) A civil year consists of 365 mean solar days, except that every fourth year one extra day is added (Leap Year.) This extra day produces an error of over three days in 400 years, therefore in the Gregorian Calendar, three days are omitted every fourth century. The average length of the civil year then coincides very nearly with the Tropical Year. *See* YEAR, TROPICAL.

——, Sidereal (*Astron.*) The interval between two successive passages of the Sun through a point on the Ecliptic, determined by a reference to some Fixed Star.

——, Tropical (*Astron.*) The interval between two successive passages of the Sun through the First Point of Aries. The Tropical Year coincides with the seasons, but does not contain an exact number of days; its length is very nearly 365 days 6 hours. For this reason the Civil Year was devised. *See* YEAR, CIVIL.

Yeast. A fungus belonging to the genus *Saccharomyces*. There are several forms, such as BEER YEAST, seen only in a cultivated form; and WINE

YEAST, occurring in the soil of vineyards. The plant consists of minute organised cells containing granular matter. The cells at a certain temperature multiply enormously by budding, and cause alcoholic fermentation.

Yellow. *See* COLOURS, PRIMARY.

Yellow, Chrome. *See* CHROME YELLOW.

——, Indian. *See* INDIAN YELLOW.

Yellow Jasmine (*Botany*). A North American plant, *Gelsemium nitidum* (*Loganiaceæ*) (*not the cultivated jasmine*), used in pharmacy as a nervine and febrifuge in the form of an alcoholic extractive (Gelsemin) and an alkaloid (Gelsemina).

Yellow Ochre (*Chem.*) An impure ferric oxide.

—— (*Min.*) A variety of Limonite (*q.v.*) used as a pigment. From Pary's Mine, Anglesea, and Saddleback in Cumberland, etc.

Yellow Prussiate of Potash (*Chem.*) A common name for potassium ferrocyanide. *See* POTASSIUM COMPOUNDS

Yellow Topaz (*Min.*) A synonym for Citrine, a clear yellow variety of Quartz (*q.v.*) *See also* PRECIOUS STONES, *p.* 539.

Yellow Wove (*Print*) A technical anomaly. It is really a blue wove paper of a cheap kind.

Yenite (*Min.*) A synonym for LIEVRITE (*q.v.*)

Yew. *See* WOODS.

Yield Point (*Eng., etc.*) When a specimen is tested in the testing machine, a sudden increase of length usually occurs when the stress reaches a certain value. The point at which this occurs is termed the YIELD POINT.

Ylang-ylang. This perfume, also known as Macassar oil, is obtained from the flowers of a Malayan tree, *Cananga odorata* (order, *Anonaceæ*)

Yoke (*Elect. Eng*) The iron portion connecting the limbs of an electro magnet.

Yolk (*Woollen and Worsted Manufac*) The actual fat, or Suint (*q.v.*), of the wool fibre. The fine wools, such as merino, may contain 50 up to 60 per cent. of fatty matter; wools of the crossbred type contain a much smaller percentage.

Yorkshire Light (*Carp. and Join*) A solid frame with one sash sliding horizontally

Young Fustic. *See* DYES AND DYEING.

Ytterbium (*Chem*) Yb. Atomic weight, 173. A very rare metal occurring in gadolinite and euxenite. It forms an oxide, Yb_2O_3, and a sulphate, $Yb_2(SO_4)_3 8H_2O$ The metal has a characteristic spark spectrum.

Yttrium (*Chem*) Yt. Atomic weight, 89 A rare metal occurring in gadolinite, samarskite, and yttrotantalite. Its separation is a long and tedious process. It forms an oxide, Yt_2O_3, and a chloride, $YtCl_3$. The oxide glows strongly when heated. The metal has a characteristic spark spectrum.

Yttrocerite (*Min.*) A fluoride of calcium with cerium and yttrium metals. Massive. It contains cerium, yttrium, lanthanum, didymium, and erbium. From near Falun in Sweden and in North America.

Yttrotantalite (*Min.*) A tantalate and niobate of iron, calcium, yttrium, erbium, and cerium; orthorhombic. Colour black or brown. Tungsten, tin, and uranium are also sometimes present. From Sweden.

Yucca (*Botany*). A well known genus of the order *Liliaceæ*, native to North and Central America. A fibre of considerable value is obtained from several species.

Zaratite (*Min.*) A synonym for EMERALD NICKEL (*q.v.*)

Zedoary (*Botany*). A perfume and tonic obtained from the tubers of *Curcuma zedoaria* (*Zingiberaceæ*), a native of India and China.

Zeeman Effect (*Phys.*) An alteration in spectral lines produced by subjecting the source of light (which may be a flame, vacuum tube, etc.) to the action of a powerful magnetic field. When the light is viewed at right angles to the lines of force, each line becomes a triplet, the middle component having the same wave length as the original line. All the lines are plane polarised, but the plane of polarisation of the central line is perpendicular to that of the outer lines. When the light is viewed along the lines of force, instead of a triplet, a doublet with circularly and oppositely polarised components is produced. These are the simplest forms deduced from the theory, and are often actually obtained, but other modifications occur, and all lines do not behave alike, some being practically unaffected. Often a further splitting up of the components takes place. For instance, one of the yellow D lines is resolved into four and the other into six constituents, and in other cases the effect is still more complicated.

Zeisel's Process (*Chem.*) A method for determining the presence and number of the groups —OR in an organic compound where R is a hydrocarbon residue of the paraffin series. Such compounds are converted by the action of concentrated hydriodic acid into hydroxy compounds, while the alkyl group is converted into iodide. *Eg.* (1)

$$\underset{\text{(Anisol)}}{C_6H_5OCH_3} + HI = \underset{\text{Phenol.}}{C_6H_5OH} + CH_3I$$

(2) Quinine contains a methoxy (OCH_3) group. (3) Codeine contains a methoxy group The substance to be examined is weighed and placed in a small flask provided with a doubly bored cork; through one opening passes a tube through which carbon dioxide is led through the apparatus, while the tube of a reflux condenser worked with warmed water passes through the other opening of the cork. To the upper end of the condenser is attached a set of potash bulbs containing water and a little red phosphorus, the bulbs are immersed in water at 50° to 60°. The potash bulbs communicate with a flask containing a solution of silver nitrate in aqueous alcohol, to which a drop or so of nitric acid has been added—usually one flask is sufficient, but a guard flask containing only aqueous silver nitrate can be added if desired. Hydriodic acid is added to the substance, and the flask is brought slowly to boiling; any hydriodic acid or iodine escaping is stopped in the potash bulbs. Methyl iodide is kept gaseous by the suitably warmed water of the condenser and potash bulbs till it reaches the alcoholic aqueous silver nitrate, where it reacts to form a double compound of silver iodide and nitrate, which is decomposed by warming on the water bath with much water and a little nitric acid. The silver iodide is weighed. The method is not applicable

without modification to compounds containing sulphur. Zeisel's method can be used to determine alcohol of crystallisation, methoxy and ethoxy groups in such compounds as acetals; and a simple modification of it serves to determine alkyl groups attached to nitrogen (methylimide groups).

Zenith (*Astron.*) The direction of a point immediately over the head of the observer. The vertical point of the heavens at any place, and consequently the opposite of NADIR (*q.v.*)

Zenith Distance (*Astron.*) The angular distance of a star from the zenith (*q.v.*) It is the complement of the altitude.

Zenith Sector (*Astron.*) An astronomical instrument consisting essentially of a portion of a graduated circle, used for accurately measuring the zenith distances (*q.v.*) of stars which pass near the meridian; also in trigonometrical surveys for finding the difference in latitude of two stations by observing the difference in the zenith distances of a particular star at the two places as it passes the meridian.

Zenith Telescope (*Astron.*) A telescope, having adjustments in altitude and azimuth, used for observing the meridian passage or transit of two stars near the zenith, one north and the other south of the zenith.

Zeolite (*Min.*) Hydrous silicates of alumina and the alkalies; they are commonly found in lavas, and occasionally in other eruptive rocks.

Zephyr (*Textiles*). A light cloth composed of fine coloured yarns, with fine sett. Woven in plain weave in either stripe or check patterns.

Zero Method (*Phys., Elect. Eng., etc.*) A method of testing in which two quantities are adjusted till they are equal; the attainment of such equality is known by the absence of any effect in an indicating instrument, *e.g.* the absence of deflection in a galvanometer used with the Wheatstone Bridge (*q.v.*)

Zeuner's Valve Diagram (*Eng.*) A diagram used in the investigation of the action of a slide valve (*q.v.*) It consists of a circle whose diameter represents the travel of the valve; two smaller circles are drawn with their centres on a diameter of the larger circle, so as to touch the latter and also each other. The displacement of the valve, the steam opening, exhaust opening, etc., can be obtained by drawing radii of the larger circle corresponding to any given position of the crank, *i.e.* at any point in the stroke of the piston.

Ziervogel Process (*Chem.*) A process for extracting silver from silver-containing copper ores or mattes. It consists of a very skilful process of roasting the material, so as to expel arsenic and antimony and a part of the sulphur. The sulphides of the charge are converted, at any rate in part, into sulphates, which are again decomposed as the temperature of the furnace is raised, except the silver sulphate. The charge is withdrawn from the furnace when the temperature approaches that at which the sulphate is decomposed. The roasted product is extracted with hot water, and the silver is precipitated from the clear solution by copper. For some extremely interesting remarks on the complexity of the process see *An Introduction to the Study of Metallurgy*, by SIR W. C. Roberts-Austen, 3rd ed. pp. 8 *et seq.*

Zigzag (*Architect.*) A form of ornament in Norman work, also termed CHEVRON (*q.v.*)

Zigzags (*Textile Manufac.*) Designs in which the twill or diagonal runs alternately to the right and left.

Zinc (*Chem.*) Zn. Atomic weight, 65·4. A white metal with faint bluish tinge; melts at 419°; boils at about 920°. The vapour density shows zinc to have a monatomic molecule. The specific gravity of the metal is 6·9, and is raised somewhat by rolling. It is most ductile and malleable between 100° and 150°, while over 200° it becomes so brittle that it can be powdered. In the air the metal becomes superficially coated with carbonate, and then undergoes no further change. When strongly heated in air it burns with a bluish white flame to the oxide. Zinc decomposes water at a red heat, but if it is impure decomposition occurs even at 100°. Hot solutions of caustic soda or potash dissolve zinc slowly, forming zincates, $Zn + 2NaOH = Na_2ZnO_2 + H_2$. Dilute sulphuric and hydrochloric acids attack zinc, but extremely slowly. If impurities are present, as in commercial zinc, which contains carbon and iron, they attack it very readily, yielding a salt and hydrogen. Hot, strong sulphuric acid acts as an oxidising agent forming the sulphate, and is reduced to sulphur dioxide and in part even to sulphuretted hydrogen. Nitric acid attacks zinc readily, forming the nitrate and various reduction products of nitric acid, such as nitrogen, ammonia, nitrous oxide, and nitric oxide. Zinc throws out many metals from solutions of their salts, *e.g.* copper, tin, lead, mercury, cadmium, silver, and gold. It is often used as a reducing agent, alone in the form of zinc dust or with an acid or alkali; for example (1) many phenols are deprived of oxygen when heated with zinc dust, ordinary phenol giving benzene, alizarine giving anthracene; (2) succinimide gives pyrrole (*see* p. 582); (3) zinc and dilute sulphuric acid reduce ferric to ferrous salts, zinc and ammonia reduce copper acetylide to ethylene; (4) coated with copper (by putting clean zinc into 3 per cent. copper sulphate solution) it forms the zinc copper couple which is often used in effecting reductions, as for example the reduction of a nitrate to ammonia, or methyl iodide to methane. Zinc occurs naturally in the form of sulphide (zincblende, ZnS), carbonate (calamine, *q.v.*), silicate (siliceous calamine, $Zn_2SiO_4 . H_2O$). To obtain the metal the ore is roasted so as to form oxide, and the oxide, intimately mixed with powdered coal, is distilled in clay retorts—a part of the metal condenses as dust. Numerous electrolytic methods for obtaining zinc have been patented, but none has yet entered into serious competition with the distillation method. Pure zinc can be prepared from ordinary commercial pure zinc by distilling it in hard glass tubes in a vacuum. Zinc is used in making galvanised iron (*q.v.*); in making many important alloys, such as brass, bronze, and German silver; as the negative pole in a number of important cells (*see* CELLS); in the extraction of gold (*q.v.*)

Zinc Alkyls (*Chem.*) *See* ZINC COMPOUNDS.

Zinc Blende (*Min.*) *See* BLENDE.

Zinc Compounds (*Chem.*) ZINC OXIDE, ZnO, is a white powder; melting point unknown. Does not melt in the oxyhydrogen flame, and volatilises in the electric furnace. Can be obtained crystalline by strongly heating in oxygen. Occurs to some extent naturally in crystalline form. Very slightly soluble in water (about 2×10^{-4} gram molecules per litre); readily soluble in acids forming corresponding salts, and in caustic soda or potash forming zincates.

When heated it turns yellow, but becomes white again on cooling. It is reduced to the metal by heating it with carbon, or in a current of hydrogen (at 450°). It may be prepared by heating the metal in air, or by heating the hydroxide, carbonate, or nitrate. On the large scale it is made by the first of these methods. Zinc oxide is largely used as a paint (zinc white); it is also much used in medicine as an ointment or alone (astringent). The hydroxide $Zn(OH)_2$ is a white solid nearly insoluble in water; soluble in acids forming zinc salts, in caustic soda or potash forming zincates, and in ammonia forming complex zinc ammonia compounds. When heated it loses water and forms the oxide. It is obtained by precipitating a solution of a zinc salt with caustic soda or potash or ammonia solutions. The precipitant must not be in excess; it can be obtained in crystals by placing zinc in contact with copper or iron in ammonia. The zincates, for example, K_2ZnO_2, are obtained in the ways mentioned above and under Zinc; they are completely hydrolysed in dilute solution. ZINC CHLORIDE, $ZnCl_2$, is a white solid usually met with in sticks which have been cast; melts about 290°; boils at 730°. It has a normal vapour density. Zinc chloride is very deliquescent, and is used as a dehydrating agent; thus it is used in the preparation of alkyl chlorides (*see* Ethyl Chloride). It is very soluble in water (1 gram molecule in 2 of water at 15°), in alcohol, glycerine, and many other organic solvents forming compounds with them. Fused zinc chloride readily dissolves zinc oxide, and the solution sets to a hard mass. An aqueous solution of zinc chloride also dissolves the oxide, and a strong solution of this kind is used in dissolving silk. Zinc chloride combines with ammonia to form several compounds, *e.g.* $ZnCl_2.NH_3$ and $ZnCl_2 2NH_3$. Both these are very stable, and are obtained by direct union of their components. The $ZnCl_2 2NH_3$ is found in Leclanché cells. This power of zinc chloride to unite with ammonia is made use of in chemistry. *See* HYDRAZONES *and* SKATOLE. Alkaline chlorides unite with zinc chloride to form double salts, *e.g.* $(NH_4)_2ZnCl_4$. A solution of this salt is used in soldering. Zinc chloride may be prepared by dissolving the metal, oxide, or carbonate in hydrochloric acid and evaporating. During the evaporation basic chlorides of uncertain composition are formed, and these must be removed by addition of concentrated hydrochloric acid, or, better, by passing hydrochloric acid gas into the liquid during the process. Zinc chloride is used in medicine as a caustic, in solution as an antiseptic under the name Burnett's Fluid (*q.v.*), and on a large scale in weighting or filling textile fabrics—4 to 5 per cent. of it has been found in such fabrics. ZINC SULPHATE, $ZnSO_4$, is a white solid obtained by heating its heptahydrate at 100° to form the monohydrate, which is then heated over 240°. It is only decomposed at a white heat; but it is easily decomposed by heating with reducing agents, *e.g.* with carbon it is reduced to oxide or to zinc according to the temperature employed. Zinc sulphate is ordinarily met with as heptahydrate, $ZnSO_4 7H_2O$, commonly called white vitriol. This salt is formed by dissolving the metal, oxide, or carbonate in dilute sulphuric acid, and crystallising the solution. On the large scale the sulphide is roasted in such a way as to form sulphate which is extracted with water. When the solution is crystallised over 50° a hexahydrate is produced; the monohydrate is obtained as above. Zinc sulphate is very soluble in water (51 grs. in 100 grs. water at 15°). With the alkali sulphates it forms double salts, such as $K_2SO_4ZnSO_46H_2O$. It is used in medicine as an emetic and as a lotion, in dyeing and calico printing, and in the preparation of other zinc compounds. ZINC CARBONATE, $ZnCO_3$: The natural form is crystalline (*see* Calamine). Artificially prepared, it is a white powder very slightly soluble in water, more soluble in water containing carbon dioxide; easily decomposed by heat, $ZnCO_3 = ZnO + CO_2$. It is obtained by precipitating a solution of a zinc salt with acid potassium carbonate. When a normal carbonate is used, partial hydrolysis results, and basic carbonates of varying composition are obtained. It is used in medicine like the oxide. ZINC SULPHIDE, ZnS: The natural form (*see* BLENDE) is crystalline. That form known as Sidot's hexagonal blende (Würtzite) is strongly phosphorescent in the *a*-rays of radioactive elements. It is the most important ore of zinc. The artificial form is usually met with as a white powder; but it can be obtained crystalline by heating it to bright redness in a current of hydrogen or by heating zinc oxide in a current of sulphuretted hydrogen. It is very slightly soluble in water and in acetic acid, but readily soluble in mineral acids even when very dilute. Heated in air it forms either the sulphate or oxide; when heated with an oxidising agent, such as sodium peroxide, it forms the sulphate. It is obtained by precipitating a zinc salt with sulphuretted hydrogen or with an alkaline sulphide. In the former case precipitation will be incomplete if the acid liberated is a strong acid, such as sulphuric or hydrochloric; but it will be complete if it is a weak acid, such as acetic. Thus half the zinc is precipitated from a solution of 1 gram of zinc sulphate in 77 grams of water on saturating the solution with sulphuretted hydrogen. In the latter case precipitation is complete. To make the precipitation complete in the case of zinc sulphate it is only necessary to add excess of sodium acetate, so that the strongly ionised sulphuric acid is replaced by the slightly ionised acetic acid:

$$ZnSO_4 + 2NaC_2H_3O_2 + H_2S = Na_2SO_4 + 2C_2H_4O_2 + ZnS.$$

Zinc combines with alkyl groups to form the ZINC ALKYLS. A typical example of these compounds is zinc methyl, $Zn(CH_3)_2$, a colourless liquid which boils at 46°; has an unpleasant and dangerous smell; takes fire, burning with the zinc flame, instantly in air, but if dry air is allowed slow access to it, it forms a kind of peroxide, probably $Zn\langle{}^{O-O-CH_3}_{CH_3}$, which is explosive and liberates iodine from potassium iodide. It is decomposed by water and methyl alcohol as follows:

$$Zn\langle{}^{CH_3}_{CH_3} + {}^{HOH}_{HOH} = Zn\langle{}^{OH}_{OH} + 2CH_4$$

$$Zn\langle{}^{CH_3}_{CH_3} + {}^{HOCH_3}_{HOCH_3} = Zn\langle{}^{OCH_3}_{OCH_3} + 2CH_4$$

With alkyl iodides it yields, on heating, paraffins, $Zn(CH_3)_2 + 2ICH_3 = ZnI_2 + 2C_2H_6$. For its reactions with acid chlorides, aldehydes, and ethyl formate, *see* KETONES, SECONDARY ALCOHOLS, *and* TERTIARY ALCOHOLS. For another kind of reaction, *see* TIN COMPOUNDS. Zinc methyl combines with ether forming $2Zn(CH_3)_2(C_2H_5)_2O$. It is prepared by gently warming a dry zinc copper couple (washed with alcohol, then ether, and the latter removed by a current of dry hydrogen) with methyl iodide. Zinc methyl iodide, $Zn\langle{}^{CH_3}_{I}$, is first formed, and yields the zinc methyl on distillation. The apparatus must be perfectly dry, and the whole operation carried

out in an atmosphere of carbon dioxide. Zinc ethyl and other zinc alkyls are prepared, and behave in a similar way to zinc methyl.

Zinc Copper Couple (*Chem.*) *See* ZINC.

Zincite (*Min.*) Red oxide of zinc, ZnO. Hexagonal, very perfect cleavage, usually found massive; deep red colour. Found in New Jersey, where it is an important ore of zinc.

Zinc Methyl (*Chem.*) *See* ZINC COMPOUNDS.

Zincography. The process of producing a design in relief on a zinc plate, for the purposes of printing. *See* PHOTO ENGRAVING, *p.* 524.

Zinc White (*Chem.*) *See* ZINC COMPOUNDS.

—— (*Dec.*) A valuable white pigment consisting wholly of oxide of zinc (*q.v.*) The term zinc white is sometimes applied to the group of white pigments which consist of zinc sulphide and zinc oxide, combined with a large proportion, say 69 per cent., of barium sulphate, of which Orr's Zinc White (*q.v.*) is an example.

Zingiberaceæ (*Botany*). A Dicotyledon order of economic importance. Well known plants of the order are GINGER (*Zingiber*), CARDAMOM (*Elettaria* and *Amomum*), and TURMERIC (*Curcuma*).

Zircon (*Min.*) An oxide of zirconium, ZrO_2SiO_2; tetragonal. Colourless, grey, green, or brownish. Found in certain metamorphic and eruptive rocks, and also in alluvial deposits. The varieties Jargoon and Hyacinth (*q.v.*) are used as gems.

Zirconite (*Min.*) A grey or brown variety of ZIRCON (*q.v.*)

Zirconium (*Chem.*) Zr. Atomic weight, 90·6. A rare metal occurring in Series 6, Group IV. of the Periodic System (*q.v.*) It forms bright grey plates; melts about 1300°, only oxidised at a very high temperature. It is obtained from the dioxide by heating with carbon in the electric furnace, when a product containing carbon is obtained, which must be again heated with more oxide to free it from carbon. The metal forms a dioxide, ZrO_2, a tetrachloride, $ZrCl_4$, a silicate, $ZrSiO_4$. The silicate is the form in which zirconium is found naturally; it is called Zircon (*q.v.*) *See* JARGOON, HYACINTH, PRECIOUS STONES.

Zither (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 429.

Zizania (*Botany*). A genus of grasses. CANADA RICE (*Z. aquatica*) is used as a cereal in North America.

Zizyphus (*Botany*). A genus of shrubs or trees of the order *Rhamnaceæ*, mostly native to tropical Asia and America. *Z. chloroxylon* yields cogwood, *Z. Lotus* an edible fruit, *Z. vulgaris* the fruit known as French jujubes, and *Z. Joazeiro* a Brazilian fodder plant.

Zn (*Chem.*) The symbol for Zinc (*q.v.*)

Zocle (*Architect.*) *See* SOCLE.

Zodiac (*Astron.*) A imaginary belt or zone in the heavens, within which the motions of the sun, moon, and planets are confined. It extends about 8 degrees on each side of the Ecliptic (*q.v.*), and was divided by the ancients into twelve parts, each distinguished by a constellation, termed the Signs of the Zodiac.

Zodiacal Light (*Astron.*) A faint pyramid of light extending from the sun both east and west along the ecliptic. Best seen in northern latitudes in the evening in February and March, and in the morning in October and November.

Zoisite (*Min.*) A silicate of iron aluminium and calcium; orthorhombic, usually in radiating groups or crystalline masses; pink to brown or grey. Found in metamorphic rocks.

Zondas (*Meteorol.*) Northerly hot winds of the South American pampas.

Zone Axis (*Min.*) An axis in a crystal which is parallel to a set of crystal planes.

Zone Plane (*Min.*) A plane normal to the Zone Axis (*q.v.*)

Zoophorus (*Architect.*) The frieze of an entablature, particularly when carved with representations of animals. *See* FRIEZE.

Zostera (*Botany*). A genus of *Potamogetonaceæ* known in Britain as "grass wrack." The plants grow in salt water on sandy shores. When dried Zostera is much used as a packing material.

Zr (*Chem.*) The symbol for ZIRCONIUM (*q.v.*)

Zymase (*Chem.*) An enzyme extracted from yeast. Nothing is known with certainty as to its chemical composition, much less as to its constitution; perhaps it is a proteid. It is obtained from yeast by expelling water by pressing it at a pressure of 50 atmospheres, rubbing the pressed mass with the finest quartz sand and kieselguhr in order to destroy the cell walls, then again pressing, first by itself, then with a little water at 500 atmospheres. The expressed juice is filtered, and contains the enzyme, along with other enzymes of a different kind, such as proteolytic and peptic. The enzyme can be precipitated from the solution by alcohol ether (2:1); when washed with alcohol and ether and dried in a vacuum over sulphuric acid, it consists of a white mass which contains the enzyme, but is far from being pure. The importance of zymase lies in its property of fermenting glucose to alcohol and carbon dioxide; it also ferments lævulose, raffinose is more slowly fermented, galactose and glycogen still more slowly, lactose and arabinose not at all. *See also* ENZYMES. Its optimum conditions for glucose are temperature 22°, concentration about 16 per cent. glucose. Acids affect its action prejudicially; alkalis in small amount promote its action. Hydrocyanic acid stops its action altogether, but the activity is recovered by passing air through the liquid for a long time.

APPENDIX

Absorption Bands (*Phys.*) *See* SPECTRUM ANALYSIS, *p.* 698.

Acetate (*Chem.*) A salt of ACETIC ACID (*q.v.*)

Acid Drip (*Chem. Eng.*) *See* DRIP, *p.* 175.

Acid Egg (*Chem. Eng.*) *See* MONTEJUS.

Acid Pump (*Chem.*) *Add to definition on p.* 5: It is sometimes operated by compressed air instead of by a piston.

Actinism (*Phys.*) The special property of radiant energy, whether luminous or not, whereby chemical changes are produced. The production of such changes.

Actinometer (*Phys.*) An instrument (1) for measuring the heat intensity of the sun's rays; (2) for ascertaining the actinic effect of light rays.

Adipocere. A light-coloured fatty substance formed by the decomposition of animal tissues under moist conditions, but removed from atmospheric air.

Aldine Edition. The term signifies a book printed at the Aldine Press in Venice by Aldus Manutius or one of his family (1494—1597). Aldine editions are celebrated for their fine typography. The term Aldine is applied, in a modern sense, to a series of books in the same style; also to a display type. *Cf.* ELZEVIER *and* BLACK LETTER.

Algraphy. *See* LITHOGRAPHY, *p.* 362.

Alignment (*Typog.*) Uniformity in the base line of printing types.

Angle of Lag (*Phys.*) *See* LAG AND LEAD.

Anode (*Elect*). The conductor by which an electric current enters. *Cf.* CATHODE, *p.* 92.

Aphelion (*Astron.*) That point, in the orbit of a planet or a comet, which is most distant from the sun. [To precede wording of definition on p. 22.]

Aplanatic (*Optics*). The term is applied to an object-glass, or a combination of lenses, which bring parallel rays to a focus without spherical or chromatic aberration.

Apochromatic (*Optics*). The term applied to a lens constructed so as to correct spherical and chromatic aberration to a greater extent than in an ordinary object-glass. *See* ACHROMATIC LENS *and* ACHROMATISM, *p.* 4.

Apogee (*Astron.*) The point, in the orbit of a planet or other heavenly body, which is farthest from the earth; the term relates especially to that point in the moon's orbit. [To precede wording of definition on p. 22.]

Artificial Silk. *See* WOOD PULP.

Ballistic Galvanometer. *See* GALVANOMETERS, *p.* 246.

Basil (*Leather*). Bark-tanned sheep skin, used for binding, etc. *Cf.* ROAN.

Batter (*Eng.*) The backward slope or inclination, from the base, of a wall, embankment, or the sides of a railway cutting. This gives resistance to the "thrust," and ensures greater stability.

Baumé Scale. *See* HYDROMETER SCALES.

Beck (*Textiles*). A vessel for holding dye liquor, etc.; also termed a BACK.

Beck's Scale. *See* HYDROMETER SCALES, *p.* 298.

Beer. To the list of adulterants, *add* Cocculus Indicus (*q.v.*)

Bench (*Gas Manufac.*) The term applied to a set of retorts used for the dry distillation of coal.

Benzine (*Chem. Tech.*) A popular term, not used in exact chemical nomenclature. Sometimes applied to a mixture of commercial benzenes; also to a light petroleum distillate better known as Benzoline, which is quite a different substance chemically. *See* BENZENE, *p.* 49.

Billets (*Met.*) Short lengths of square bars (blooms) of iron or steel fed to the roughing rolls of a mill for conversion into light sections of merchant iron or rails. *Cf.* PILES.

Black Plates (*Met.*) The name given to sheet iron intended for tinplates, before it is tinned.

Black Tin (*Met.*) The term applied to comparatively pure tin ore, *i.e.* ore which has been subjected to various dressings.

Block Tin (*Met.*) Add to definition on p. 55: The term is also applied to articles (1) made entirely of tin, (2) made of tinplate (*q.v.*) of superior quality.

Bog Iron Ore (*Min.*) This is sometimes used for purifying coal gas. *See also p.* 57.

Bottom (*Mining*). The floor or bed rock on which a coal seam lies.

Bottoms (*Chem. Tech.*) (1) A general term for impure residues, *e.g.* caustic soda bottoms. (2) The term applied to colours which serve as a foundation for other colours in dyeing fabrics.

Bow (*Music*). *See* MUSICAL INSTRUMENTS, *p.* 427.

Broach (*Tapestry Manufac.*) The needle or small spindle used for inserting the weft.

—— (*Tools*). (1) A stonemason's chisel, with narrow point. (2) A kind of gimlet or bit used for boring a cask.

Bucking Kier (*Linen Manufac.*) A vessel in which linen cloth is boiled with lime water in the first process of bleaching.

Burr. This term is applied to various tools used for abrading or drilling purposes, *e.g.* a fluted reamer; to a mortising chisel of rectangular section; to a blank punched from a sheet of metal.

Burrstone *or* **Burrh** (*Min.*) A silicious rock which is dressed and used for millstones.

Cadency (*Her.*) *See* LABEL, *p.* 334.

Cal., cal. An abbreviation of CALORIE (*q.v.*, p. 81). *See also* UNITS.

Camp Sheathing, Camp Sheet, Camp Shed (*Civil Eng.*) A plank structure placed at the foot of a sloping embankment or soft cutting to resist the thrust or prevent the soil from washing away.

Canopic Vase (*Archæol.*) A vase of peculiar shape, used by the Egyptians as a receptacle for a portion of the entrails of embalmed bodies, and by the Etruscans for holding the ashes of the dead. The lid represented a human head, the arms being sometimes added in the case of Etruscan vases, which were also provided with handles.

Carriage Gain (*Cotton Spinning*). *See* RATCHING.

Cartier's Scale. *See* HYDROMETER SCALES, *p.* 298.

Carton. A thin pasteboard used for making boxes. A box of this material.

Cementite (*Chem., Met.*) *See* IRON, *p.* 319.

Centroclinal Dip (*Geol.*) *See* QUAQUAVERSAL, *p.* 584.

Chemical Pulp. *See* WOOD PULP, *p.* 851.

Circumferentor. A small graduated wheel which revolves on a handle. Used for measuring the length of a wheel tyre.

Climate. *See* METEOROLOGY, *p.* 396.

Clump *or* **Clunch** (*Mining, etc.*) A coarse kind of clay. Specifically the compressed clay that occurs in coal strata.

Clumps (*Typog.*) Pieces of metal of same height as leads (*q.v.*) and cast to thickness of the bodies of type, usually nonpareil, brevier, long primer, and pica.

Clypeus (*Archæol.*) (1) A large circular shield, convex on the outer and concave on the inner side. *Cf.* SCUTUM *and* TARGE. (2) A sculptured representation of a shield hung in the intercolumniation of the atria in Roman buildings.

Collimation. (1) The accurate adjustment of the line of sight of a telescope, transit instrument, etc. (2) Bringing into line the axes of two lenses, or telescopes, which are then said to be "in collimation." (3) Determining or correcting the deviation of the line of sight of a telescope by means of a collimator. *Error of Collimation*: The deviation of the line of sight of a telescope from a plane at right angles to the axis on which it turns. This must be allowed for or corrected in observations. *Line of Collimation*: The correct line of sight or optical axis.

Collimator. (1) A subsidiary fixed telescope with fine wires or spider lines in its focus, used to determine or correct errors in collimation. (2) The tube of a spectroscope (*q.v.*) that carries the slit and contains lenses for rendering parallel the rays intended to fall on the grating or prism.

Collotype, Collodiotype (*Photo.*) A photograph made by a process (generally the wet process) in which the plate is coated with sensitised collodion. *See* WET PROCESS *under* PHOTO ENGRAVING, *p* 523, *and* PHOTOGRAPHY, *p.* 525.

Commensal (*Biol.*) An animal or plant that lives with another, as a tenant, but not at the expense of the host, *i.e.* it is not a true parasite (*q.v.*)

Continental Conditions (*Geol.*) The geological conditions prevailing in large land areas, remote from the sea; characterised by low rainfall, scarcity of rivers, presence of salt lakes, etc.

Conveyor (*Chem. Eng.*) An endless travelling belt; a chain carrying plates or trays; or a spiral worm in a trough; used for transporting solids. Certain types are called CREEPERS. ROCKERS take the form of a long trough (with cross ridges) to which a reciprocating motion is given. The aerial ropeway is a type of bucket conveyor, but of a different order to the usual form of conveyor. *Cf.* ELEVATOR.

Copy Holder (*Typog.*) A boy or girl who reads the "copy" or manuscript aloud while the Reader (*q.v.*) verifies the proof.

Cords (*Bind.*) *See* BANDS, *p.* 39.

Coumalic Acid (*Chem.*) *See* PYRONES, *p.* 578.

Coumalin (*Chem.*) *See* PYRONES, *p.* 578.

Cyanides. *See* GAS MANUFACTURE (C), *p.* 250.

Desmotrophy (*Chem.*) *See* TAUTOMERISM, *p.* 748.

Die Stock (*Eng.*) *See* STOCKS AND DIES, *p.* 723.

Downtonian Rocks (*Geol.*) *See* LUDLOW ROCKS, *p.* 368.

Drosser (*Glass Manufac.*) An iron frame used for separating the "tables" in glass making. *See* GLASS MANUFACTURE, *p.* 258.

Dust Destructor. A form of furnace in which house refuse, cinders, etc., are burnt. The material is first dried by exposure to the heat of the furnace, and then consumed under forced draught. *See also* WASTE PRODUCTS, *p.* 834.

Earth Colours (*Dec.*) A term sometimes applied to those colours or pigments which are found in nature, such as ochre, sienna, umber, etc.

Eutectic (*Met., etc.*) Fusing easily, *i.e.* at a low temperature. The term is applied to compound substances, *e.g.* alloys, the fusing point of which is lower than that of the constituents themselves. "The ratios in which metals unite to form the alloy possessing the lowest melting point are never atomic ratios, and when metals do unite in atomic ratios the alloy produced is never *Eutectic*. Metallic alloys are true homologues of the cryohydrates."—F. GUTHRIE in *Nature*.

Feeder (*Print.*) The person who feeds the sheets of paper into a printing machine—the "layer-on." The word also describes a mechanical contrivance for superseding hand labour in this operation.

Ferrite (*Chem., Met.*) *See* IRON, *p.* 319.

Figurine (*Art*). A small figure or a group of small figures made of various materials, *e.g.* metal, pottery; used for decorative purposes. *Cf.* TANAGRA FIGURINES, *p.* 743.

Fishing (*Eng., etc.*) (1) The operation of joining rails, etc., by means of fish plates. *See* FISHED JOINT *and* FISH PLATES, *p.* 223. (2) The removal of sulphate of ammonia crystals from the saturator. *See* GAS MANUFACTURE (C), *p.* 250.

Flot (*Geol.*) A northern English lead miners' name for certain lateral extensions of ore proceeding from a metalliferous vein into the country rock. Flots occur only in connection with those parts of the vein which consist of limestone.

Fob (*Soap Manufac.*) *See* FITTING, *p.* 223.

Funnel (*Chem.*, *etc.*) Generally a widemouthed conical apparatus, having a tube at the apex. Used for filling vessels with narrow openings, filtering, etc.

Fuse (*Elect. Eng.*) *See* SAFETY FUSE, *p.* 630.

Gas, Coal. *See* GAS MANUFACTURE, *p.* 248.

Geographical Mile. *See* WEIGHTS AND MEASURES, *p.* 843.

Glazed Pig (*Met.*) *See* BLAZED PIG, *p.* 54.

Gramaphone. *See* PHONOGRAPH, *p.* 520.

Gums. *See also* RESINS, *p.* 610.

Gyrostat (*Phys.*) An instrument used in experiments on the properties of rotating bodies, *e.g.* to show that the axis of a rotating body tends to retain its position in space, independent of any motion which may be given to its supports. It consists essentially of a heavy fly wheel whose axle is supported so that it can set itself in any direction.

Half-space Landing (*Build.*) *See* STAIRCASE, *p.* 707.

Halvans, Halvings, Hanaways (*Mining*). A Cornish term for ore refuse or inferior ore.

Hand Loom (*Weaving*). *See under* SILK, *p.* 673.

Hand Whip (*Mining*). A primitive contrivance consisting of a long pole, pivoted on a suitable support. A bucket for raising water, etc., is suspended from one end, and a counterbalance weight is attached to the other.

Hanging Wall (*Mining*). The upper "wall" or overhanging side of an inclined lode.

Hartshorn, Spirit of. *See* SPIRIT OF HARTSHORN, *p.* 703.

Heading Joints (*Carp.*) The joints between the ends of floor boards, *i.e.* at right angles to the edges.

Heading Side (*Mining*). The lower side of a lode.

Head Race (*Eng.*, *Mining*, *etc.*) The race or channel which conveys water to a water-wheel. *Cf.* TAIL RACE, *p.* 742.

Heave (*Mining*). A fault (*q.v.*) which raises a lode.

Hitch (*Mining*). A slight fault whose throw is less than the thickness of the seam or vein.

Hole (*Mining*). The expression "to hole" is used in various senses—*e.g.* (1) the making of an opening from one working, etc., to another; (2) undermining or undercutting so that the mineral may fall by pressure.

Horse (*Mining*). A mass of unprofitable material (country rock, etc.) separating two parts of a lode or seam.

Horse Fat. At one time horse fat was obtained from the neck only of the horse, and that fat is still more valued than fat from other parts of the body, as it is whiter and more solid. Neck fat is of the consistency of lard, except in very warm weather; while other horse fat is practically liquid, except in the winter. The two kinds of fat also differ in smell; and while the neck fat is a pure white, the other has a yellow colour, with a strong dirty brown tinge. The very best specimens of neck fat have no smell at all. Horse fat is usually mixed with bone grease, and it is difficult to get it pure. The average specific gravity of the neck fat is about 0·92. The fat of the kidneys, however, is nearly as heavy as the neck fat. In veterinary practice horse fat is employed as an ointment; but its main use is in soap manufacture, more particularly for soft soaps. Horse fat also finds a limited use for lubrication, as some practical men consider it best for certain classes of machinery. Harness makers use it for greasing leather, and wool combers use it locally where it is readily obtainable. The marrow of the horse is a yellow fat, solid at any ordinary temperature. It yields a very hard soap with caustic soda, but is very rarely used alone. Mixed with other fats, especially bone grease and cotton seed oil, it is used in soft soap manufacture. It presents no difficulties in working, and the amount of alkali required for saponification is about one-fifth of its own weight, which is about the average of fats generally, if we exclude cocoanut and palm kernel oil. These fats are used for the better classes of soap, and are never used with horse fat. Adulteration of horse fat with bone oil is best detected by determining the iodine number. This is 84 for horse fat, and never exceeds 70 for bone oil, being usually about 67. Hence any iodine value distinctly below 84 probably denotes adulteration with bone fat.

Hurdling (*Mining*). Passing ore through a coarse screen or sieve.

Hushing *or* **Hush** (*Mining*). Washing away the loose ground covering a vein lying near the surface by a sudden rush of water.

Hydraulic Mining, Hydraulicking. Working loose ore-bearing rocks (*e.g.* gravel containing gold) by a powerful jet of water.

Hygiene. The branch of medical science that deals with the preservation of health in regard to individuals and communities. *See* SANITATION, *p.* 635.

Incense. *See* THUS, *p.* 768.

Iserine (*Min.*) *See* ILMENITE, *p.* 302.

Kalpis (*Pot.*) *See* CALPIS, *p.* 82.

Kier (*Textiles*). A vat in which textiles are bleached. *Cf.* BECK *and* BUCKING KIER.

Kilo. *See* WEIGHTS AND MEASURES, *p.* 843.

Knot. Literally one of a series of knots placed at regular intervals in a log-line, the distance between two knots bearing the same relation to a mile as half a minute does to an hour, *i.e.* $\frac{1}{120}$. In common use, however, the term knot is employed as an equivalent for NAUTICAL MILE (*q.v.*) or for a speed of one nautical mile per hour. *See also under* WEIGHTS AND MEASURES, *p.* 843.

Lamella, *pl.* **Lamellæ.** The diminutive of Lamina. A thin plate or scale. *See p.* 340.

Lava (*Geol.*) A rock of volcanic origin which has solidified from a fluid mass at or near the surface. *See* ANDESITE, TRACHYTE, BASALT, RHYOLITE, etc.

Liquation, Eliquation (*Met.*) The process of heating ores or alloys in order to separate the metals, the one that has the lowest melting point being first obtained. The process is employed in refining tin.

Literals (*Typog.*) The mistakes of the compositors in single letters only, *viz.* the taking up a wrong letter or inverting a right letter.

Locking Stone *or* **Locking Pallet** (*Watches and Marine Chronometers*). The jewel fixed in the detent of a chronometer escapement for the purpose of arresting the advance of the escape wheel at the conclusion of every impulse. *See* DETENT, *p.* 156.

Lustra Cellulose (*Artificial Silk*). *See* CELLULOSE, *p.* 94, *and* WOOD PULP, *p.* 852.

Machining (*Print.*) The term used to express the operation of printing by machine. *Cf.* PRESSWORK.

Majuscule (*Palæography*). A capital or uncial letter; originally written separately, but later cursively—subsequently replaced by the new cursive, developed from the Minuscule (*q.v.*) *See also* UNCIAL, *p.* 809.

Marquetry (*Furniture*). Veneer of different woods forming a mosaic design.

Mechanical Pulp. *See* WOOD PULP, *p.* 851.

Mill (*Met.*) That department of an ironworks in which the blooms and rough bars from the "forge" (which has also shingling and rolling machinery) are piled, reheated, and rolled into merchantable iron.

Milling (*Chem. Eng.*) The process by which toilet soap is perfumed and prepared for the tablet dies. Thin chips of dried "stock" soaps are passed between granite rollers, travelling at different speeds, so that the soap is rubbed and squeezed together as well as crushed. Perfumes, etc., are generally incorporated during the milling.

Minuscule. (1) The cursive script hand developed from the semi-uncial between the 7th and the 9th centuries. It formed the basis of the small Greek and Roman letters of modern times. (2) A lower-case letter as opposed to an upper-case letter. *Cf.* MAJUSCULE (*and* UNCIAL, *p.* 809).

Modulator (*Music*). *See* TONIC SOL-FA, *p.* 777.

Möellon (*Chem. Eng.*) *See* SOD OILS, *p.* 689.

Moloxide (*Chem.*) *See* OXYGEN, *p.* 488.

Montejus (*Chem. Eng.*) The equivalent of an acid egg. A pistonless pump for raising acids, etc., by compressed air.

Morocco (*Leather Manufac.*) *See also* PERSIAN, *p.* 511, *and* ROAN, *p.* 618.

Mud Drum (*Eng.*) A cylinder attached by pipes to the lowest part of the boiler. It receives the feed water, and is supposed to allow the mud and sediment to settle out before the water rises into the boiler shell. Not in universal use, filtration of the feed water being much more effectual and safer, as unless protected from direct heat they are liable to burn and become dangerous. In tubular boilers they are sometimes provided as part of the design. The growing belief that a boiler is not a sludge tank but an evaporator is disposing of their use.

Nogging Pieces (*Carp*). The horizontal pieces of quartering fixed between the studs of a partition to stiffen it.

Oils. *See also* LUBRICANTS, *p.* 367.

Optics. The study of phenomena of light and vision, and of the various instruments employed in connection therewith.

Overblow (*Met.*) In the Basic steel process, after the carbon has been removed in the Bessemer converter, the "blow" is continued for another two or three minutes, during which the phosphorus in the charge is eliminated. Also called the AFTER-BLOW.

Peristaltic (*Elect.*) The term used by Lord Kelvin to describe the kind of electrostatic induction that occurs between conductors enclosed in the same insulator, *e.g.* in an ocean cable.

—— (*Physiol.*) The term applied to the wave-like and involuntary contractile muscular movements (peristalsis) of any hollow organ of the body, especially the alimentary canal, whereby the contents are propelled onwards.

Pole (*Silk Manufac.*) A term synonymous with pile, *e.g.* pole warp = pile warp. *See* PILE (*Textiles*), *p.* 532.

Pseudomerism (*Chem.*) *See* TAUTOMERISM, *p.* 748.

Raising Gig (*Woollen Manufac.*) A machine that raises a nap on cloth.

Red Prussiate. Another name for POTASSIUM FERRICYANIDE (*q v.*), p. 552.

Selective Absorption. *See* SPECTRUM ANALYSIS, *p.* 698.

Sienna (*Paint.*) *See* BURNT SIENNA, *p.* 77, *and* TERRA DI SIENNA, *p.* 759.

Soffit (*Build.*) The head-lining of a door or window opening. The underside of a flight of stairs or balcony, looking upwards.

Sparking Plug (*Motors, etc.*) A miniature arc lamp, between the terminals of which a low or high tension spark is passed by means of a current obtained from a storage battery or magneto machine. It is placed in the combustion chamber of an internal explosion motor to fire the gaseous fuel. The main conductor is insulated by embedding it in a plug of glass, porcelain, mica, or other fireproof insulating material. The plug and conductor are mounted in a brass or other metal screw collar or union which carries a wire terminal, bent to face the main conductor at the base of the plug. The points of the terminals can then be adjusted to leave a sparking "gap" of about $\frac{1}{16}$ inch.

Stall Board (*Carp.*) The boarding inside a shop window on which the goods are displayed.

Standard Cell (*Elect.*) A form of primary cell whose E.M.F. is accurately known and not liable to much variation. It is not used to produce a current, but as a standard of electromotive force for comparison with other electromotive forces, calibration of instruments, and similar processes requiring a standard.

Strata, Table of (*Geol.*) Stratified rocks are tabulated by the geologist according to age, which is determined by consideration of the fossils contained in the rocks, and by the physical relations of the different beds one to another. A number of beds are grouped together into SYSTEMS, *e.g.* the CARBONIFEROUS SYSTEM, which includes the various SERIES known as the Coal Measures, Millstone Grit, and Carboniferous Limestone Series. Each series is further classified according to the natural division into separate beds, which may vary in different places. The various Systems are further grouped together into PRIMARY, SECONDARY, TERTIARY and POST-TERTIARY, or QUATERNARY ROCKS; another set of rocks, older than any of the foregoing, are termed ARCHÆAN or PRE-CAMBRIAN (*see p.* 557).

With the advance of geological knowledge, modifications of the recognised classification continually occur. Thus there are reasons why the Dyas should be treated as Secondaries rather than as Primaries, and the method of division of the Cambrian, Ordovician, and Silurian Rocks is still the subject of much discussion. The classification most generally adopted is shown in the following table, which follows the method of Lapworth:

QUATERNARY *or* ANTHROPOZOIC.	POST-TERTIARY		Recent; Raised beaches, etc. Pleistocene *or* Glacial deposits	Most of the animals and plants at present existing.
TERIARY *or* CAINOZOIC.	TERTIARY	Upper	Pliocene: Norwich Crag, Red Crag, etc. Miocene: Absent in Britain	Plants and animals closely resembling those now living.
		Lower	Oligocene: Upper (absent in Britain); Hempstead Beds, etc.; Headon Beds Eocene: Bagshot Beds; London Clay; Lower London Tertiaries	
SECONDARY *or* MESOZOIC.	CRETACEOUS	Upper	Chalk Upper Greensand, Gault	Abundant animal life: the gigantic reptiles of the Jurassic Rocks occur, and a number of species of birds. Plant remains include those of the Jurassic system, with the addition of many higher forms. Thus in the Cretaceous Rocks of Germany, the Oak, Walnut, and Fig occur, and many additional species are found in America.
		Lower	Lower Greensand Wealden	
	JURASSIC	Upper	Portland and Purbeck Beds Kimmeridge Clay Corallian and Oxford Clay	Numerous fishes, reptiles (*Ichthyosaurus*, *Plesiosaurus*, *Dinosaurus*, and *Pterosaurus*), the earliest known bird (*Archæopteryx*), and certain marsupial Mammalia. Lower forms of animal life are numerous. Many plants occur, the most important being Cycads and Conifers.
		Middle	Great Oolite Inferior Oolite	
		Lower	Upper Lias Marlstone *or* Middle Lias Lower Lias	
	TRIAS	Keuper	Marls, Sandstones, etc.	Reptiles: Amphibia (*Labyrinthodonta*). Fishes: Crustacea (*Estheria*, etc.), Mollusca (*e.g.* *Ceratites*), Brachiopods (*Terebratula*, *Spirifer*). Certain plants, *e.g.* *Equisetum*, *Voltzia* (a Conifer), and Cycads.
		Muschelkalk	Shell limestone (Central Germany)	
		Bunter	Sandstones and Pebble Beds	

PRIMARY or PALÆOZOIC.	DYAS (Permian)	Magnesian Limestone, etc. Permian Sandstone	Corals, Bivalves, Fishes, Amphibians, and the first Reptiles (*Proterosaurus*).
	CARBONIFEROUS	Upper: Coal Measures (Upper Coal Measures; Main Coal Measures; Gannister); Millstone Grit Lower: Carboniferous Limestone Series (Yoredale Rocks; Mountain Limestone; Lower Limestone Shales)	Extensive plant remains, *e.g.* Ferns, Equisetum, and Lycopods (Club Mosses). Marine fossils, *e.g.* Corals, Echinoderms, Mollusca, Fishes, Amphibia (*Labyrinthodonta*).
	DEVONIAN (Old Red Sandstone)	Upper Pickwell and Petherwin Beds. Middle Ilfracombe Beds Lower Lynton Beds	Numerous characteristic Fishes: a certain amount of plant life (Sea-weeds and plants allied to the Equisetum and to the Tree Ferns), Brachiopods, and some Trilobites.
	SILURIAN	Upper *or* Downtonian Rocks Middle *or* Salopian (Ludlow, Wenlock) Lower *or* Valentian (Tarannon, etc.)	Numerous Trilobites, Mollusca, Graptolites, Corals; the earliest remains of land plants, and of Fishes.
	ORDOVICIAN	Upper *or* Caradoc Rocks Middle *or* Llandeilo Lower *or* Arenig	Graptolites are here the most important fossils. Trilobites are also common, as well as Brachiopods, and Cephalopods, Lamellibranchs, and Echinoderms occur.
	CAMBRIAN	Upper: Tremadoc Slates; Lingula Flags Lower: Menevian Group; Harlech Group	Trilobites are the most characteristic fossils. A number of Mollusca and Molluscoida (Brachiopods) are found; no Vertebrates or land animals.
ARCHÆAN.	PRE-CAMBRIAN ROCKS (*see* p. 557)		

Terne Plate (*Met.*) A kind of tinplate (*q.v.*), the coating of which consists of an alloy of lead and tin.

Turning Piece (*Build.*) A piece of timber cut to shape, to form a half-brick arch on.

Wale, Wale Piece (*Civil Eng.*) A piece of timber fastened horizontally to a row of piles, etc., to receive the impact of vessels. The horizontal part of a CAMP SHEATHING (*q.v.*)

CORRIGENDA

Agar-Agar. *For* Red Sea weeds *read* red sea-weeds.

Alcoholimetry (*Chem.*) *Read* **Alcoholometry.**

Allen's Governor. *For* value (last line) *read* valve.

Amorino. *Read* in architecture *after* often used.

Angle of Flexture (*Eng.*) *Read* **Angle of Flexure.**

Aperture (*Photo.*) The definition should read: The *diameter* of the "stop" or opening through which the beam of light *transmitted* by *a* lens must pass.

Aphelion (*Astron.*) *For* PERHELION *read* PERIHELION.

Apse *or* **Apsis** (*Astron.*) Substitute definition: The point of an eccentric orbit where the planet is either farthest from or nearest to the centre of attraction, termed respectively the higher apse and the lower apse. These terms are applied also to elliptic orbits. The apses of a planet are its APHELION (*q.v.*) and PERIHELION; those of the Moon its APOGEE and PERIGEE.

Archæology. *After* appertains to *read* man in.

Architecture, p. 25, line 25. *For* Erectheum *read* Erechtheum.

Armature (*Elect. Eng.*) *For* magnetic lens *read* magnetic lines.

Balance Wheel (*Clocks and Watches*). Refer to the definition under **Balance** (*Watches*), which is the modern term. *See also* **Balance Spring.**

Bands (*Bind.*) *For* in the back *read* on the back.

Baryto Calcite (*Min.*) *For* $BoCO_3$ *read* $BaCO_3$.

Batten Lay *or* **Lathe** (*Silk Manufac.*) *Read* **Batten, Lay** *or* **Lathe.**

Beam, p. 45, col. 2, line 12. *Read* co-efficient of elasticity (E).

Beer (line 10). *For* arsenic containing *read* arsenic-containing.

Bifilar Suspension (*Phys.*) *For* constant (8th line) *read* continuous.

Block Tin. *For* Refined Tin *read* Grain Tin.

Bone (*Zool.*) The word "calcium" should be repeated before carbonate and before fluoride. *For* cheifly *read* chiefly.

Calcium Compounds (*Chem.*), p. 81, line 21. *For* Gypsum, $CaSO_4 2H_2O$ *read* Gypsum, $CaSO_4 . 2H_2O$.

Candle. *After* during combustion (4th line from end) *read* and their low illuminating power.

Carbolic Acid. *For* so violent a poison (2nd line from end) *read* a violent irritant poison.

Caryatid (*Architect.*) *For* Erectheum *read* Erechtheum.

Cements (*Build.*) *For* solution of lime (5th line from end) *read* solution of alum.

Chronometer. *For* dedent *read* detent.

Circumferenter. *Read* **Circumferentor.**

Colours (*Pigments*), p. 119, 2nd column, line 8. *For* cadmium, *read* cadmium yellow.

Colours, Complementary. For (*Pigmeuts*) read (*Pigments*).

Cross (*Her.*) Fig. 1, legend line. *For* CLECHÉE *read* CLECHÉE FITCHÉE.

Declination (*Astron.*) *For* horizon *read* equator (p. 152).

Dressing (*Mining*). *For* TRUE VANNER *read* FRUE VANNER.

Engraving, p. 203. HOLLAND. *For* Rembrant *read* Rembrandt.

Fitting (*Soap Manufac.*) *For* NEST SOAP (4th line from end) *read* NEAT SOAP.

Gathering (*Bind.*) *For* volume from *read* volume form.

Gum Animé, p. 273. *For* **Animé** *read* **Animi.**

Musical Instruments, p. 427, line 16. *For* cymbals *read* cymbalo.

Opoponax, p. 477. *Read* **Opopanax.**

Overstep (*Geol.*) *Read* A stratum is said to *overstep* another . . . etc. (p. 483).

Paper, p. 496, line 29 from end. *For* stiff chests *read* stuff chests.

Pile (*Textile Manufac.*) *For* cut; or left in loop, *read* cut, or left in loops.

Ptomaines (*Chem.*), p. 569, line 14. *Read* substances obtained from corpses, which have basic properties, and show the general reactions of the plant alkaloids.

Pynknometer. *Read* **Pyknometer.**

Rhyolite (*Geol.*) *For* crumbling *read* crumpling.

Speed Gears, p. 699, col. 2, line 32. *For* sun *read* sum.

Tungsten (*Chem.*) *Read* Atomic weight 184.

Wall Rib, p. 832. *For* BIB *read* RIB.